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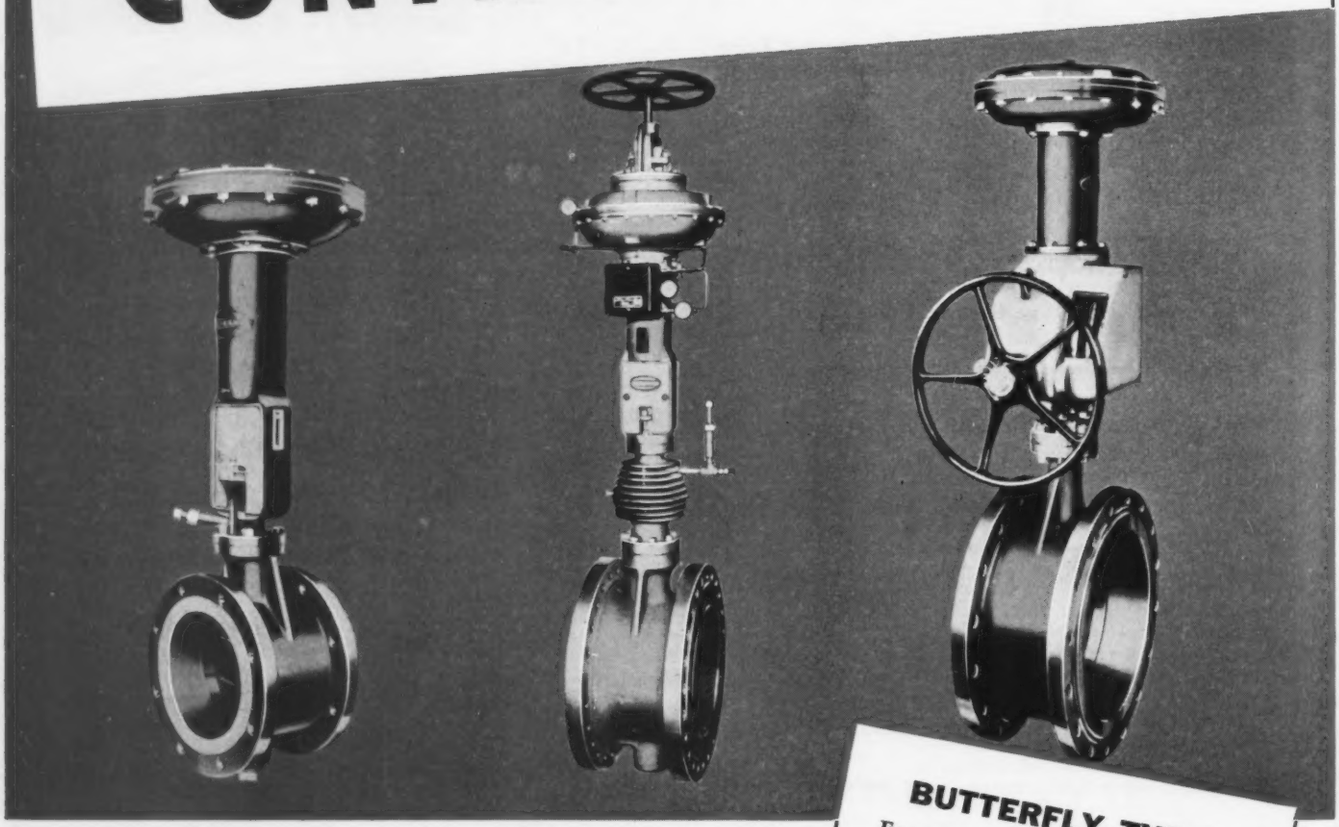

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VOLUME 20, No. 12 DECEMBER, 1941

REFINER
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The Look Box

MOST heartening of the moves made by Petroleum Coordinator Harold L. Ickes was his formation of the Petroleum Industry Council for National Defense, which had its first meeting December 8 and is scheduled to meet each month in the future.

Vehicle for Coordination

Although it is too early to estimate accomplishments of body, it is comforting to know that representatives from the industry now will have opportunity to take part in deliberations which concern what the industry can do and what it will be expected to do in providing the fuels and lubricants for the national defense program.

There has been too much of finality in Washington. Orders come out and leave no opportunity for consideration. All too frequently what is demanded is either difficult to accomplish or could be accomplished by other means and only the industry can determine the proper means.

The hulabaloo of the shortage on the East Coast was an example. As soon as the matter came under scrutiny of the government there was finality in the attitude that sufficient gasoline could not be delivered to that area. Then service station sales were cut down 10 percent, while threats were made to indicate still further curtailment.

Subsequent events provided that the problem could and should have been handled without all the fanfare of shortage. The industry had to alter and augment its transportation facilities and some tankers had to be returned to coastwise service. The industry knew how to augment and alter its transportation facilities. Government should have known that tankers could be had from England. Conferences in the light of what each party knew would have saved all the time and talk devoted to "shortage."

This council will be valuable in handling situations of this sort.

IF LEFT to its own devices the petroleum industry can solve the few little problems that face it. The inconsistent phase of the situation is that government, which is demanding so much of the industry, is preventing the industry from accomplishing what government seeks.

If Left To Itself

All indications are that refining plants must process more than 4,000,000 barrels of oil daily for the first half of 1942. This, according to reliable figures, is close to 100 percent of capacity for refining plants east of the Rocky Mountains. Most plants are running close to 100 percent now.

In a few instances, especially along the Texas Gulf Coast, plants are running at around 75 percent of capacity because crude oil is not available. Proration regulations simply do not permit these plants to have sufficient crude oil of the sort needed for full-capacity operation. In the absence of intricate processing equipment, these plants need oil from particular fields in excess of allowables of the Texas Railroad Commission. Perhaps that condition exists elsewhere.

If the regulatory bodies were concerned with plant output rather than with "inequalities" as

between oil fields, plant output could be stimulated thereby.

It is true, also, that crude oil is being consumed at a pace higher than reserves are being added. While this is not a problem in refining, the situation is one wherein government is responsible for preventing a higher rate of exploratory drilling. As the history of the industry proves, the most effective means of stimulating discovery is a higher price for crude oil.

But while one agency of the federal government warns of the disparity between consumption and discovery, another agency of government frowns effectively on higher crude oil prices.

If the need for more oil is as pressing as statistics indicate, more oil is of far greater consequence than is the quotation on a price for a barrel of oil. Perhaps it is too much to expect economic planners to get the idea, but a few million barrels of oil needed and not on hand would be priceless beyond dollar quotations.

There are indications that stocks, both raw material and finished products, should be increased. The lowest stock total within two decades is no pleasing picture in the glow of a crisis. But that is the situation.

Meanwhile, even men within the industry are striving to prevent any increase in stocks. Evidently these men believe continued forced shortage will bring higher prices. The price consideration here is of about as much value as it is in official Washington, where the effort is to keep quotations at present levels.

It would be well if both the government and conflicting interests within the industry would back away from quotations and regulations and let the old and effective play of supply and demand have a hand in coming to that desirable situation of sufficient crude oil in tanks and sufficient products in other tanks.

The industry itself has accomplished that in the past. It can do it again, if left to itself.

The Price Is Not the Thing

ALTHOUGH the logic of the reasoning is confusing, it seems at times that official Washington mistakes the price of a product for a sufficiency of the product. Only recently the Office of the Price Administrator has fixed some prices, in one instance oil, in the other steel drums, and the wonder of it all is how either of these acts is to contribute to the supply of either.

In the case of oil, the explanation has been given that the order is not for the purpose of preventing price increases but rather to hold a price spiral in check until cases can be studied. In the case of steel drums, the administrator made an order on the basis that prices simply had gone too high, so high that the drum often was worth more than its contents.

Equally confusing is how effective these orders are when the administrator admits that he has no authority. Evidently authority is not needed, as fear seems to be equally effective.

If the whole program in Washington has any objective it is to help in providing additional supplies of materials, oil and steel drums included. Price tampering will not provide an additional barrel of oil and it will not increase the number of steel drums, either new or used. The contrary is true. Higher prices for any product will augment supply more effectively than a truck load of official orders.

Perhaps the confusion has Washington in hobbles. Some agencies admit their objectives of increasing supplies. But others write orders which will curtail supplies.

Keep Kicking Gasoline Tax Around

ALTHOUGH there has been improvement in the movement to have all of the gasoline-tax dollar spent on highway building and maintenance part of it still goes to other purposes and even in highway building there is a tendency to divert gasoline tax money to county roads and city streets.

The American Petroleum Industries Committee recently gave this split in the spending of the gasoline-tax dollar: 28 cents goes to highway construction 19 cents goes to highway upkeep; 19 cents goes to local roads; 12 cents goes to debt retirement; 16 cents goes to non-highway purposes.

It is interesting to note the growth in diversion to local roads, as the committee sums it up:

"In 1923 a total of $15,000,000 of the gasoline-tax revenue was shared by the states with the counties. In 1940, despite the fact that the counties had turned over to the states more than 250,000 miles of road, the counties' share of the state gasoline tax revenues stood at $160,548,000."

Another observation concerning debt retirement is that bond issues double the cost of roads. Interest and other services on the debt make a mile of road cost twice what it would had the cash policy been followed.

Just plain diversion, use of gasoline-tax revenue for other than highway purposes, is decreasing and is now restricted to a dozen states.

The other 2 cents of the tax dollar goes to collection, administration cost, traffic control and similar purposes.

Turbines for Power Generation From Industrial Process Gases

JOHN GOLDSBURY and JOHN R. HENDERSON
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THIS paper presents a discussion of the fields of application for turbines operated by industrial process gases and natural gases, examples of the mechanical details of actual turbines which have been built for such applications, a simple method for calculating the energy available in a pure or a compound gas for specific operating conditions, and the properties of various gases for use in such calculations. After a study of the available data on gas properties, the authors have selected for the working curves what they considered most authentic.

This paper was presented before the meeting of the American Society of Mechanical Engineers, Louisville, Kentucky, October 16, 1941.

MANY modern industrial processes involve the production or use of gases or vapors under pressure. It is apparent that certain desirable reactions take place more effectively under pressures above atmosphere. In some cases the gain in the quality or quantity of the product seems to be well worth the cost of air or gas compression. In the case of natural gas, the compression as well as the gas itself is contributed by nature. In any case, when a continuous flow of gas is available under pressure above atmosphere, it will be well to consider whether advantage cannot be derived from expanding the gas through an elastic fluid turbine.

This term elastic fluid turbine is used to denote the general class of turbines which are operated by the expansion of any gas or vapor. The general features are the same as those of the steam turbine, but the dimensions, materials and design details will be determined by the particular elastic fluid used as well as by the pressures and temperatures involved.

Not only may it be found that the use of a turbine will improve some established processes or increase the economy of operation, but the possible advantages of a turbine may turn the balance in favor of new processes being considered.

In some cases certain difficulties may arise, such as corrosiveness of the gas, presence of liquid, gummy or solid particles carried by the gas or arising from physical or chemical changes, etc. If, however, the advantage of using the gas in a turbine is great, ways of overcoming these difficulties can frequently be found.

In general, the justification for a turbine would be the power which it could produce, but an increasing number of processes are being considered in which the advantage of the turbine is the reduction in gas temperature due to the energy absorbed by the turbine. At least one such application has been made and several others have been considered.

The most important development so far in the use of turbines driven by industrial process gases other than steam is found in connection with certain catalytic petroleum refining processes. In these processes carbon is deposited on the catalyst. The carbon must be burned off and the catalyst regenerated at frequent intervals. In several of these processes it is apparently most effective and economical to burn off the carbon under pressure. In some cases the pressure is as high as 300 pounds and much higher pressures have been proposed. Several catalyst retorts are frequently used so that one or more can be undergoing the regeneration processes continuously. The maximum regeneration temperature is controlled either by tubes through which a coolant is passed or by recirculation of some of the products of combustion which have passed through a waste-heat boiler or by other suitable means. There is, then, a steady flow of these products of combustion or flue gas which is of no further use to the process. The heat could, of course, be partially recovered in a waste-heat boiler or other type of heat exchanger, but the pressure potential would be largely wasted. The pressure potential can be utilized and a large portion of the heat removed by passing the gas through a turbine.

The illustration in Figure 1 shows a 3500-horsepower flue-gas turbine on the test floor. A cross section view through this turbine is shown in Figure 2. The description given below indicates some of the problems which must be considered in connection with such turbines.

With some grades of process charge sulphur will be deposited on the catalyst. This will appear as SO_2 in the flue gas. In order to avoid corrosion from this, as well as from any other possible corrosive component in the gas, it was decided to make the rotor, buckets, nozzles and some other parts of this particular turbine of a high grade of stainless steel, while a low-alloy steel was used for the casing parts. Valve trim was of stellite, interior packings were of a special cast iron and outer shaft packings of carbon. Recent tests have indicated that less expensive and more easily workable materials will probably be suitable for many of the parts when the corrosive components of the gas are only SO_2 and water.

As further protection against corrosion it is planned so far as possible to operate the turbine only at exhaust temperatures will above the condensation points of any acids likely to be present in the gas. When the turbine is to be shut down for any extended period, hot dry air or neutral gas will be blown through the casing, packing glands and valves to purge out all traces of the gas, and precautions will be taken to prevent any gas from leaking into the turbine during such periods.

Although no solid materials in appreciable quanti-

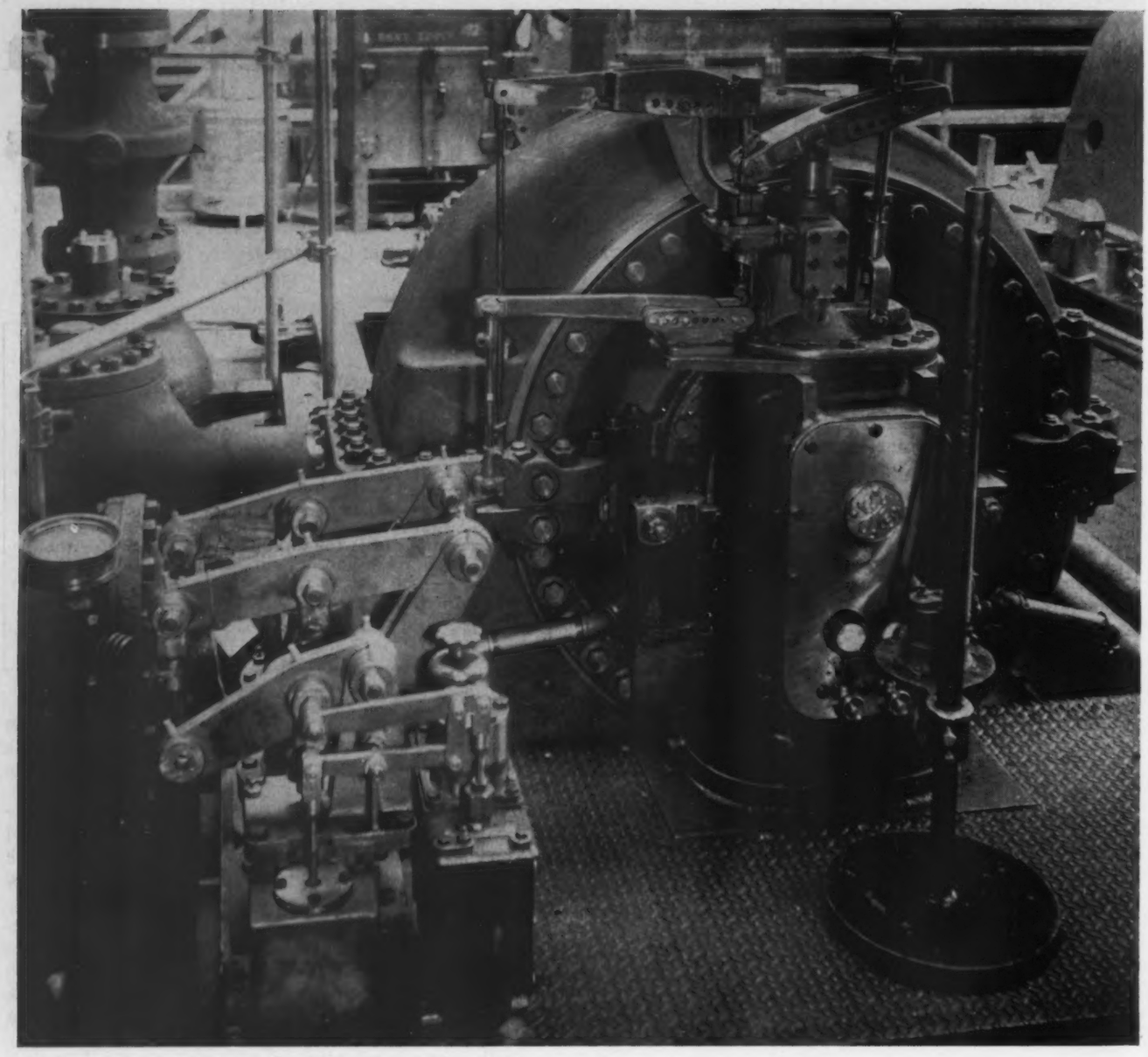


FIGURE 1

ties are expected to be entrained with the gas, provision has been made for the admission of air to the shaft packing glands, if that is necessary to prevent such material from settling in the packings. Space has been allowed for assembly of special interstage packings which can also be sealed with air if experience indicates the need.

Because of the large coefficient of thermal expansion of the stainless steel rotor, it was necessary to use particular care in designing packing and other clearances to prevent any possibility of rubbing, even under large and rapid changes in load or operating conditions. In general, the turbine was designed for simplicity and ruggedness rather than highest efficiency. The first of the three stages is velocity compounded with two rotating bucket rows and with circular nozzle ports. Maximum turbine efficiency, together, doubtless, with other refinements contributing to plant economy, can come later, when the experience necessary for determining the best over-all arrangement is available.

The diagram in Figure 3 shows the control arrangement for this turbine. The mechanism is such that speed can be held constant at any set value within the setting range of the governor, in this particular case, from 2800 to 4000 rpm. The speed governor (a) controls a single admission valve (b) through an oil-operating cylinder, not shown. In order to assist the speed governor in holding constant speed in spite of large variations in gas-main pressure, a constant-pressure governor (c) is used to control the pressure ahead of the speed-governing valve. The pressure governor controls a valve (d) which by-passes excess gas around the turbine. Fluid restoring links, not shown in the diagram, permit very close net speed and pressure regulation combined with instantaneous regulation broad enough to be stable.

This particular turbine was designed to be installed out of doors, and the sheet metal lagging, oil-tank cover, etc., were consequently made weatherproof.

In Figure 4 is shown the control diagram for an-

other flue gas turbine of 885 horsepower capacity. In this case a 1460-horsepower steam turbine is coupled to the same shaft for starting and for supplementing the gas turbine power.

Referring to the diagram, it will be seen that both turbine admission valves, (b) and (d), are controlled by one speed governor (a) through oil relays. The linkage is arranged in such a way that the gas-turbine valve (d) opens first, the steam-turbine valve (b) then opening to whatever extent is necessary to make up the difference between the load required and the power which can be obtained from the gas turbine under the particular conditions considered. The steam valve has an overtravel in the closed position, so that it does not lift above its seal until the gas valve is nearly wide open.

Although there is only one speed governor, a separate emergency overspeed governor is provided on each turbine, to prevent runaway of either turbine or case of loss of its load. The emergency governor (f) on the gas turbine will dump the oil pressure from the gas-admission-valve cylinder (e) only, while the emergency governor (g) on the steam turbine will dump the oil pressure from both the gas- (e) and steam- (c) admission-valve cylinders, to cover the case of complete loss of load on the compressor.

The governing mechanism also includes a device, not shown on the diagram, to admit a small steam flow to the steam turbine to carry away the heat resulting from windage of the buckets, rotating idly while the compressor is being driven by the gas turbine. Steam is also supplied to the shaft seals of the gas turbine, to prevent leakage of gas.

The speed setting of the governor (a) can be regulated either automatically by the pressure control (h) or manually by the hand-wheel (i).

Natural Gas

Another large potential field for power from expansion of gas through turbines is the natural gas industry. It has been calculated that the total work which might theoretically be thus extracted from the annual production of natural gas in the United States is of the order of one and three quarters billion kilowatt hours.* Numerous very small turbines of standard steam designs are being operated by natural gas and

* Based on 1939 production of 2,435 billion cubic feet—World Almanac, 1941.

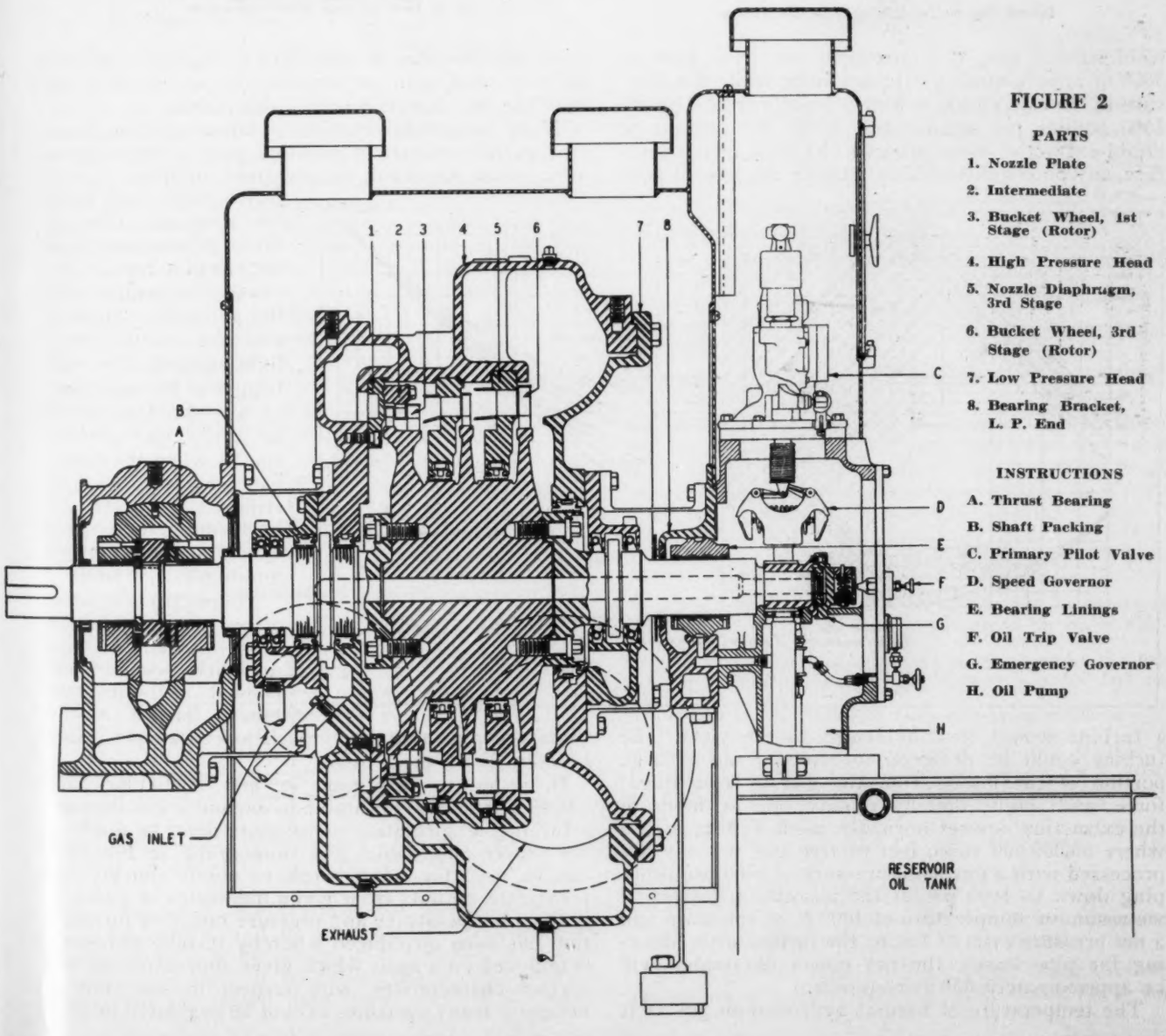


FIGURE 2

PARTS

1. Nozzle Plate
2. Intermediate
3. Bucket Wheel, 1st Stage (Rotor)
4. High Pressure Head
5. Nozzle Diaphragm, 3rd Stage
6. Bucket Wheel, 3rd Stage (Rotor)
7. Low Pressure Head
8. Bearing Bracket, L. P. End

INSTRUCTIONS

A. Thrust Bearing
B. Shaft Packing
C. Primary Pilot Valve
D. Speed Governor
E. Bearing Linings
F. Oil Trip Valve
G. Emergency Governor
H. Oil Pump

used to drive pumps and other apparatus. However there are undoubtedly many cases where no power is derived from expansion of the gas, but where the pressure drop from the well to the point of use is much greater than is really needed to overcome friction losses in pipes of reasonable size.

In the repressuring process of liquid extraction from natural gas, well pressures run from 1500 to 3000 or more pounds per square inch, while the pressure in the absorption tower is usually from 1000 to 1500 pounds per square inch. Since the amount of liquid extracted increases with decrease in temperature, any power extracted by passing the gas through a turbine would contribute also to the yield. The turbine could be designed to separate out a large portion of the liquid from the gas by centrifugal force, and might thereby replace one or more of the extraction devices normally used. Taking a case where 50,000,000 cubic feet of free gas per day are processed with a gas main pressure of 2000 psi. dropping down to 1000 psi. at the absorption towers, if we assume a temperature of 100° F. at the main and a net pressure ratio of 1.8 for the turbine after allowing for pipe losses, the net power obtainable will be approximately 650 horsepower.

The temperature of natural hydrocarbon gas as it issues from the wells is very low compared with that of combustion gases. It is frequently less than 120° F. When such gas is expanded through a turbine, the temperature at the turbine outlet may be below freezing. This not only requires the use of materials which retain their ductility and strength at such low temperatures, but also introduces a possible difficulty from ice formation. If considered advisable, moisture, hydrates, and even carbon dioxide can be removed from the gas before it enters the turbine.

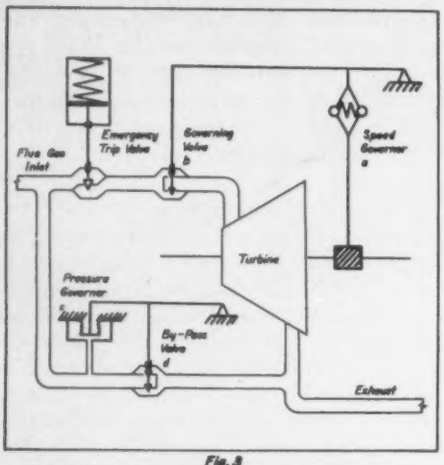


Fig. 3
Control Diagram for 3500 Hp. Flue Gas Turbine

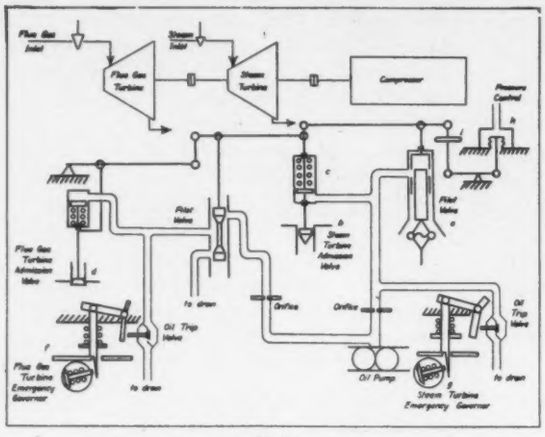
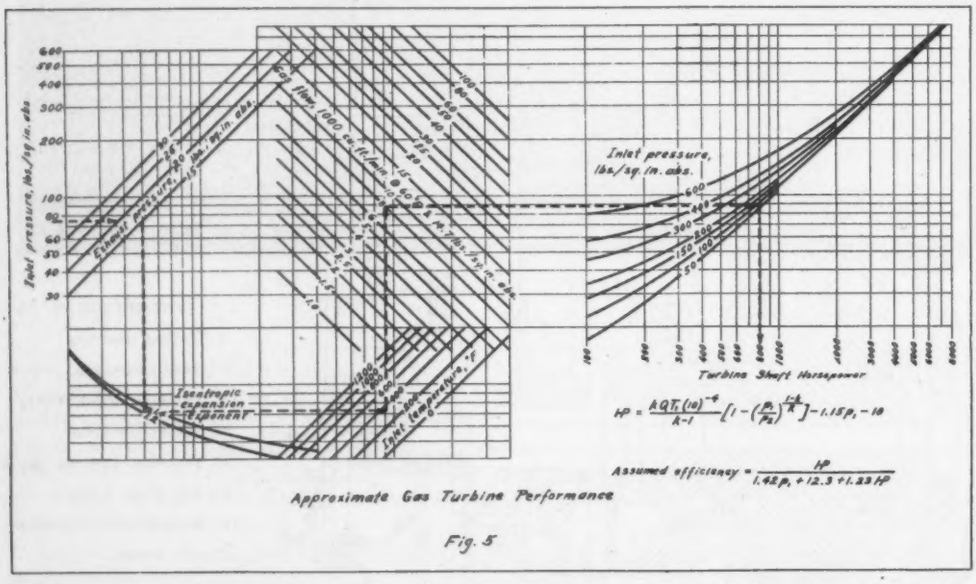


Fig. 4
Governing Mechanism for Dual Drive
Flue Gas Turbine and Steam Turbine—Compressor Set

In one natural-gas application where turbines were used to drive electric generators, special precautions were taken to avoid danger from ignition of gas which might leak from the packings. One of these precautions was the use of a firewall between the turbine and the generator. Another was the use of beryllium copper for the trigger of the emergency overspeed governor in order to prevent sparks when the emergency governor bolt strikes the trigger. An explosion-proof speed synchronizing control motor was also used.



Approximate Gas Turbine Performance

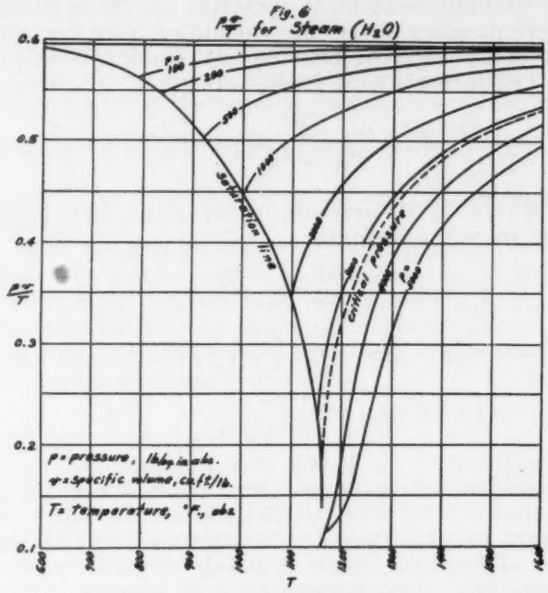
Fig. 5

There are, of course, other processes than those mentioned above in which gases are expanded through turbines, but it would seem probable that very much more can profitably be done along these lines.

In order to determine in any particular case whether it will be profitable to expand a gas through a turbine, a calculation or estimate must be made of the power obtainable. The nomograph in Figure 5 can be used for rough work to obtain quickly approximate outputs from given quantities of gases at various temperatures and pressure ratios. A formulation has been introduced whereby turbine efficiency is included on a basis which gives approximately the correct characteristic with respect to size, but of necessity many variables cannot be evaluated in such

a chart. The reduced size of the chart due to page space limitations in itself precludes accurate results, but for very rough approximations it may be found useful.

An example of the derivation of turbine output by the use of the nomograph in Figure 5 is given at the



end of the paper. For comparison the same example is also worked out by the method described below.

For more accurate determinations something must be known of the properties of the gas and suitable methods must be used to calculate the available expansion energy. Though much work has been done on measurement of the thermodynamic properties of the common gases, the reports of many of these measurements are scattered through various periodicals and other publications. A large amount of work is necessary to assemble this data and convert the various quantities to common English units. For the convenience of engineers who wish to use these properties, the p-v-T relationships of several common gases are given here. In general the com-

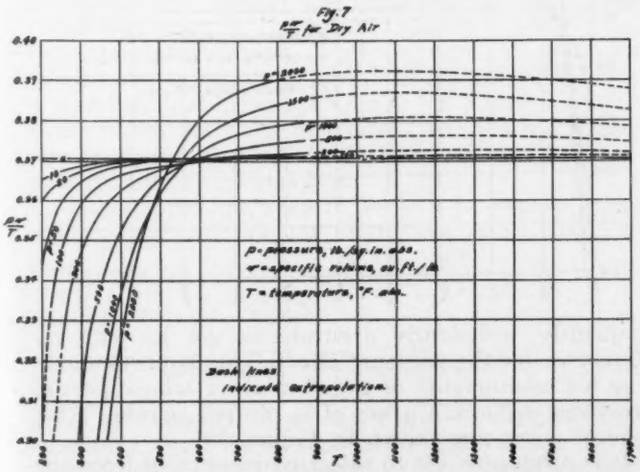
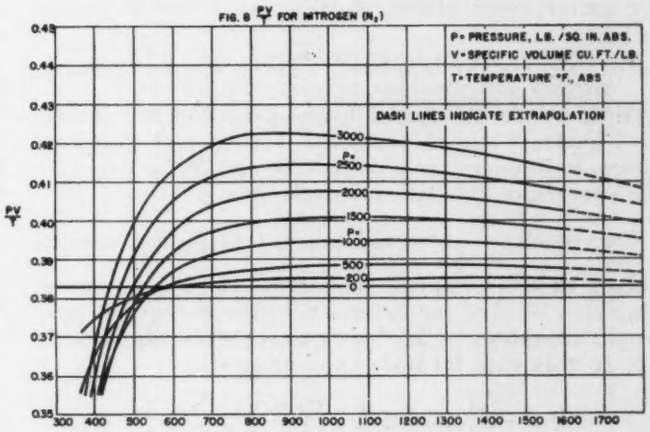


Fig. 7
pv/T for Dry Air
p = pressure, lb./sq.in.abs.
v = specific volume, cu.ft./lb.
T = temperature, °F. abs.
Dash lines indicate extrapolation.

plete range of temperatures for which data were found is given, and in several cases extrapolations have been made by means of the Beattie-Bridgman equation of state or by other means. The range of pressures for which data were given was usually more than adequate for normal use. These p-v-T relations are presented on charts which are necessarily of restricted size, but determinations from them will be accurate enough for most purposes.

A method for obtaining quite accurately turbine inputs or theoretical power outputs for superheated gas expansions is described below. This method has been found very convenient for such calculations. For a pure gas the accuracy of the results depends chiefly on the accuracy of the available data on the properties of the gas and on the accuracy of the secondary data derived from the basic data. In calculations with superheated steam through a very wide range of initial pressures, initial temperatures and pressure ratios, the inaccuracies due to the approximations of the method itself are seldom as great as one half of one percent when compared on the basis of available energy per pound with those derived directly from the Keenan and Keyes tables. Since both the basic and derived steam properties are also taken from these tables and from the accompanying curves, the comparison was between two methods of deriving available energies from these properties.

The method being described is based on the assumption that if the initial specific volume can be



found and if a suitable mean value of isentropic exponent can be obtained, the available energy from the expansion of one pound of any gas from given initial pressure and temperature to a given final pressure can be determined from the formula

$$E = \frac{144}{778} p_1 v_1 \frac{k}{k-1}\left[1 - \left(\frac{p_1}{p_2}\right)^{\frac{1-k}{k}}\right] \qquad (1)$$

Where E is the available energy in Btu. per pound of gas,
p_1 is the initial pressure in pounds per sq. in. absolute,
p_2 is the final pressure in pounds per sq. in. absolute,
v_1 is the initial specific volume in cubic feet per pound,
and k is the mean isentropic expansion exponent.

If the gas flow is given in cubic feet per minute of free gas, (60° F., 14.7 pounds per square inch, absolute) the turbine output in horsepower is

$$\frac{Q \times 60 \times M \times E \times e}{2545 \times 380} = 6.2\ (10)^{-3}\ QMEe \qquad (2)$$

Where Q is the gas flow,
M is the molecular weight,
and e is the turbine efficiency, which must be assumed or obtained from the manufacturers.

For a perfect gas, k is constant throughout the expansion and the formula is exact. Also, for a per-

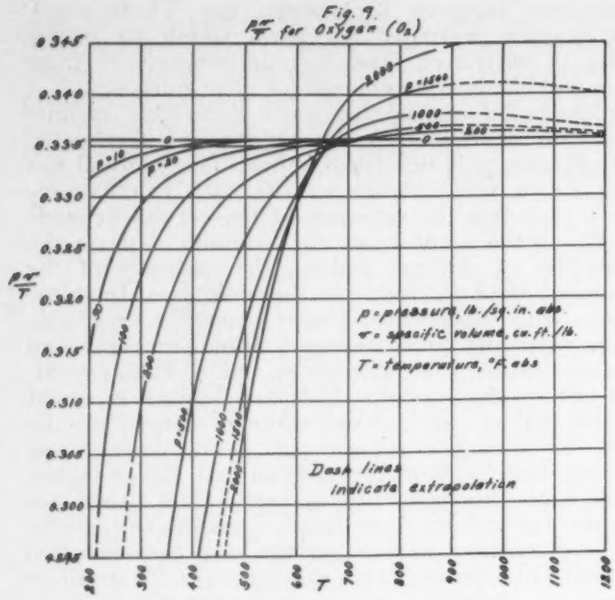


Fig. 9.
pv/T for Oxygen (O2)
p = pressure, lb./sq. in. abs.
v = specific volume, cu. ft./lb.
T = temperature, °F. abs.
Dash lines indicate extrapolation

fect gas, $p_1 v_1 = R T_1$. With temperature, T_1, in degrees Rankine or Fahrenheit absolute, and p and v in the unites given above, $R = \frac{10.72}{M}$. With all actual gases $\frac{p v}{T}$ is not constant. Curves of $\frac{p v}{T}$ plotted against temperature at different pressures are shown in Figures 6 to 14 inclusive, for several common gases. References are given at the end of the paper to the sources of the data for each chart.

Curves of $\frac{E}{p_1 v_1}$ plotted against p_1/p_2 for various values of k are shown in Figure 15. These curves may also be used for determining the energy of isentropic compression by using the curves above k = 1.0. In this case formula (1) becomes

$$E = \frac{144}{778} p_1 v_1 \frac{k}{k-1}\left[\left(\frac{p_2}{p_1}\right)^{\frac{k-1}{k}} - 1\right] \qquad (1a)$$

Enlarged curves for greater accuracy can readily be

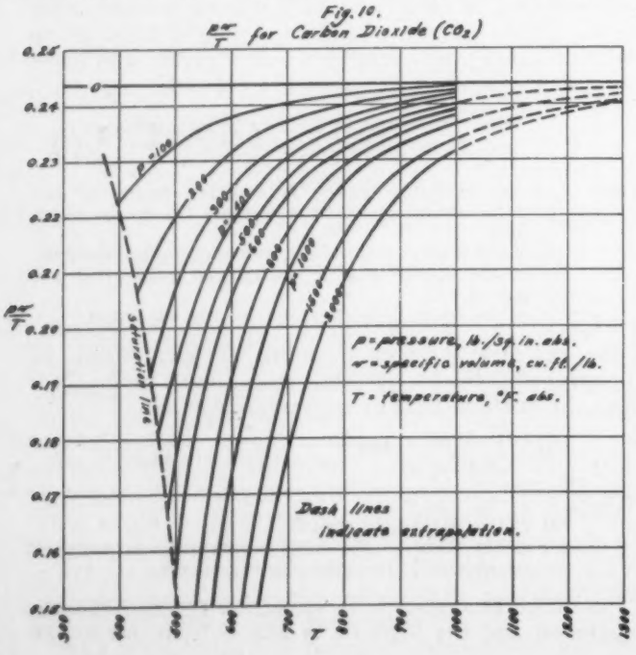


Fig. 10.
pv/T for Carbon Dioxide (CO2)
p = pressure, lb./sq. in. abs.
v = specific volume, cu. ft./lb.
T = temperature, °F. abs.
Dash lines indicate extrapolation.

prepared from calculations using formulae (1) and (1a). Plotting $\frac{E}{p_1 v_1}$ against k for constant values of p_1/p_2 facilitates accurate interpolation, but many curves are required.

Curves of k vs. T for constant values of p are shown in Figures 16 to 18 inclusive for three gases. The zero pressure curves are calculated from the new values of C_{p_o} derived from spectroscopic investigations. The formula used for k_o was

$$K_o = \frac{C_{p_o}}{C_{p_o} - \frac{1.985}{M}} = \frac{C_{p_o}}{C_{v_o}} \qquad (3)$$

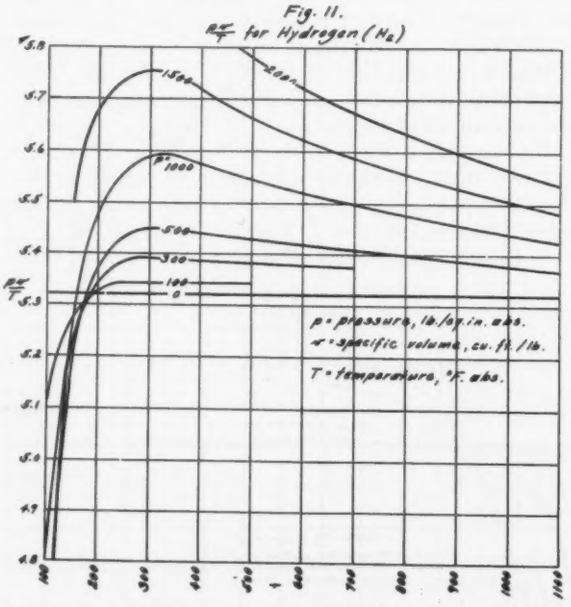
Values of k at pressure other than zero were derived from the formula

$$k = -\frac{v}{p}\left(\frac{\partial p}{\partial v}\right)_T \frac{Cp}{Cv} \qquad (4)$$

$$\text{where } Cp = C_{p_o} - \int T\left(\frac{\partial^2 v}{\partial T^2}\right)_p \partial p \qquad (5)$$

$$\text{and } Cv = Cp + T\frac{(\partial v/\partial T)^2_p}{(\partial v/\partial p)_T} \qquad (6)$$

Calculations of k using this formula are quite laborous. The derivatives were obtained by taking the ratios of differences at small intervals. The consisitency of these differences was improved by taking second differences, and drawing smooth curves through them, then calculating new primary differences from the smoothed second differences. Fortunately, except at large pressure ratios, the energy per pound of gas is not sensitive to the magnitude of k, within the normal range. For this reason, it is



frequently sufficiently accurate to use k_o with no allowance for the pressure effect. This is particularly true for components of a gas mixture whose partial pressures are low. Curves of k_o plotted against T for several gases are shown in Figure 19.

It is often possible to select by inspection from the curves a value of mean k which is sufficiently accurate for ordinary requirements. Where greater accuracy is required, the following method will help.

Consider first the case of a gas for which only curves of k_o against temperature are available. The end temperature, T_2, for isentropic expansion can be

calculated, using an assumed value of mean k from the formula

$$T_2 = T_1\left(\frac{p_1}{p_2}\right)^{\frac{1-k}{k}} \qquad (7)$$

A mean value of k between T_1 and T_2 can then be determined. Usually it is sufficiently accurate to use the value of k at the mean temperature, $\frac{T_1+T_2}{2}$.

If curves of k are available for a sufficient range of both temperature and pressure, calculate T_2 by formula (7). If the temperature drop is small, it will be sufficiently accurate to use $k_m = \frac{k_1+k_2}{2}$, where k_1 is read from the curves at p_1 and T_1 and k_2 at p_2 and T_2.

Since the path of isentropic expansion on the k — T plane may not be a straight line, it will be well, in the case of large pressure ratios, to divide the temperature drop up into two or more approximately equal parts. The end pressure for each successive expansion can be determined from the formula

$$p_2 = p_1\left(\frac{T_1}{T_2}\right)^{\frac{k}{1-k}} \qquad (8)$$

the subscripts in this case referring to the beginning and end points of the partial expansions. A mean value of k can then be determined for each partial expansion and these averaged to obtain an overall k_m.

If it is found that the assumed value of k_m used in formula (7) is too far off from the final value, the process must be repeated.

In the case of gas mixtures the accuracy of this method will depend also on the accuracy of the method used for obtaining the combined properties as well as on the time which can be given to deriving curves of combined properties. Combined values of $\frac{pv}{T}$ based on Amagat's law are usually more reliable at high pressure than those based on Dalton's law. Combined values of $\frac{pv}{T}$ for many of the hydrocarbon gases and some others can be obtained with good accuracy from charts of generalized properties based on reduced pressures and temperatures and on pseudo critical pressures and temperatures. This method was developed by W. B. Kay[1] and is described in "Industrial Chemical Calculations" by Hougen and Watson. This book contains a great deal of useful information on gases and gas mixtures. What is probably a still more accurate, but rather laborious method, also described in Hougen and Watson's book, was developed by Prof. E. R. Gilliland[2] of Massachusetts Institute of Technology.

Assuming Amagat's law to hold, an assumption which is sufficiently accurate for most work at any but very high pressures, combined values of $\frac{pv}{T}$ can be readily obtained from the formula

$$\text{Combined } \frac{pv}{T} = \frac{p_1v_1}{T_1}b_1 + \frac{p_2v_2}{T_2}b_2 + \ldots \qquad (9)$$

The subscripts 1, 2, etc. here refer to the individual values for the several component gases taken at the same pressure and temperature that are being considered for the mixture. b_1, b_2, etc. are the fractional parts by weights of the component gases.

A method of obtaining values of combined k which is justified by the perfect gas laws, has been proposed by Allen Keller, Mechanical Engineer, General Electric

FIG. 12.
$\frac{PV}{T}$ FOR METHANE (CH_4)

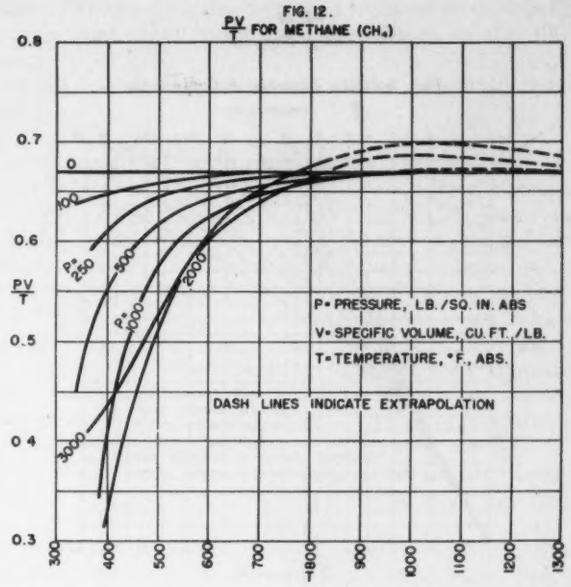


FIG 13.
$\frac{PV}{T}$ FOR ETHANE (C_2H_6)

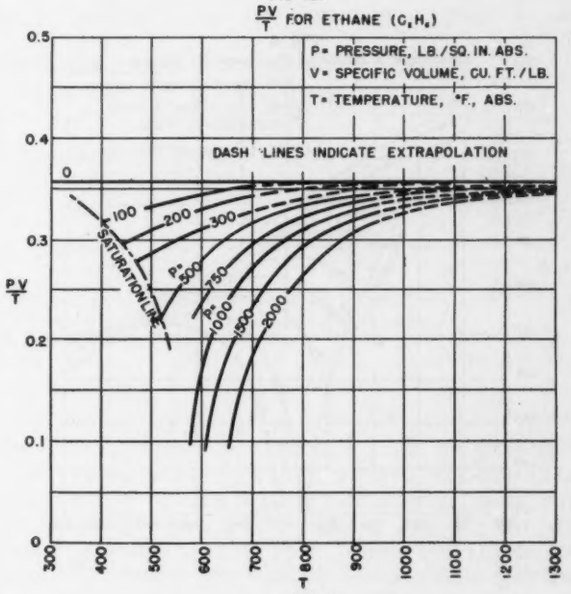


FIG. 14
$\frac{PV}{T}$ FOR PROPANE (C_3H_8)

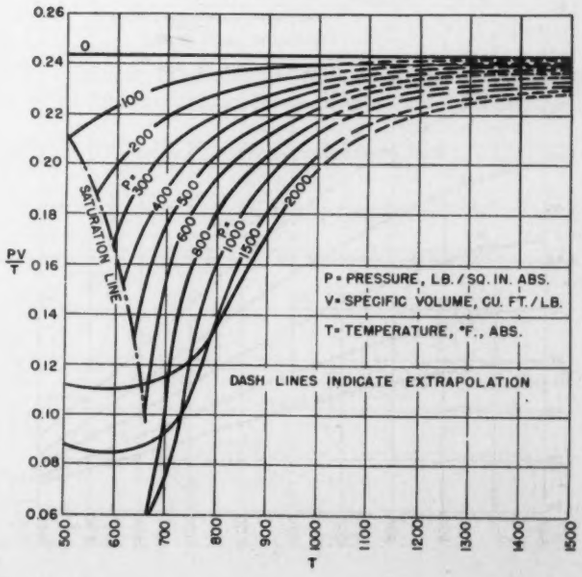


Fig. 15
Exergy Function

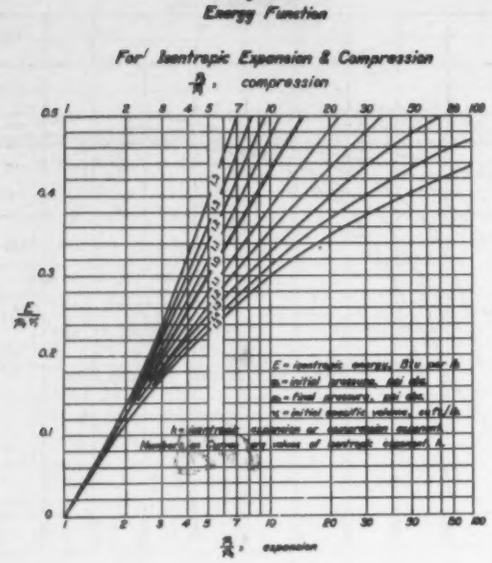

For Isentropic Expansion & Compression
compression
expansion
E = isentropic energy, Btu per lb.
p1 = initial pressure, lbs. abs.
p2 = final pressure, lbs. abs.
v1 = initial specific volume, cu. ft./lb.
k = isentropic exponent or isentropic constant.
Numbers on curves are values of isentropic constant, k.

Fig. 16
Isentropic Expansion Exponent For Steam

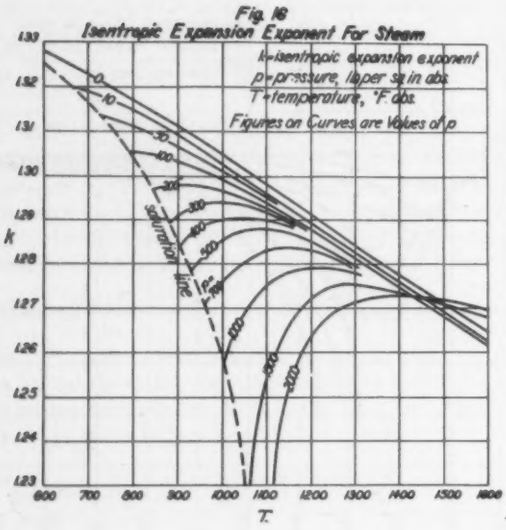


FIG. 17
ISENTROPIC EXPANSION EXPONENT FOR NITROGEN (N_2)

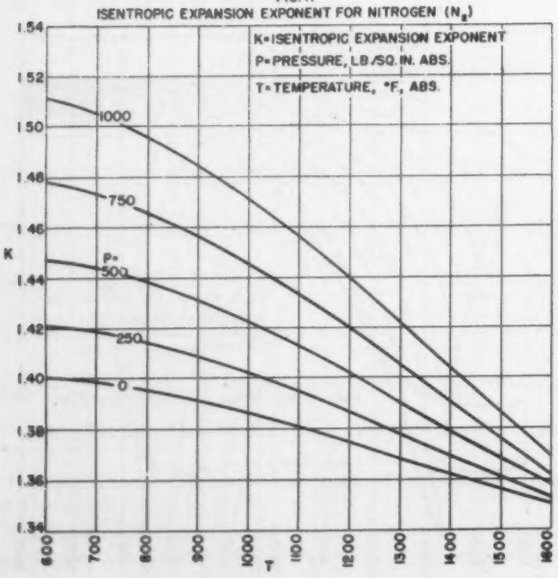


Fig. 18
Isentropic Expansion Exponent for Methane

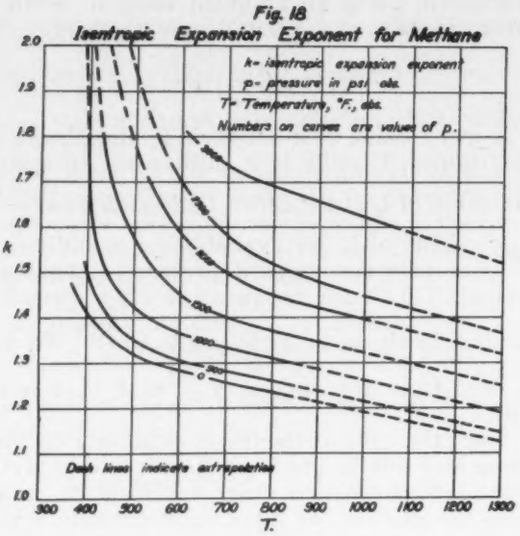


Fig. 19
Isentropic Expansion Exponent
For Various Gases at Zero Pressure

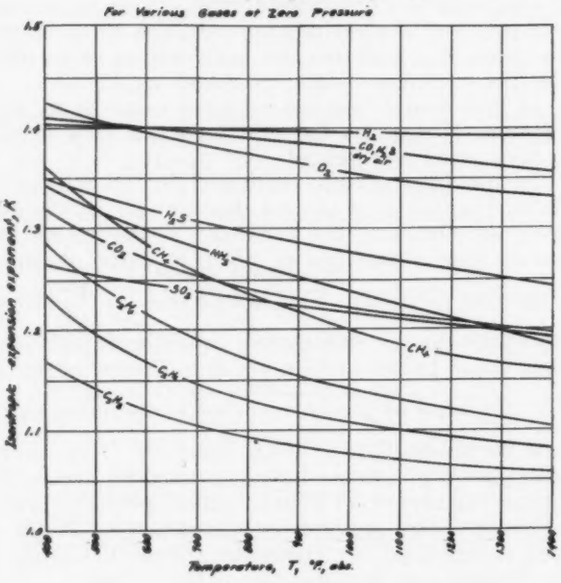
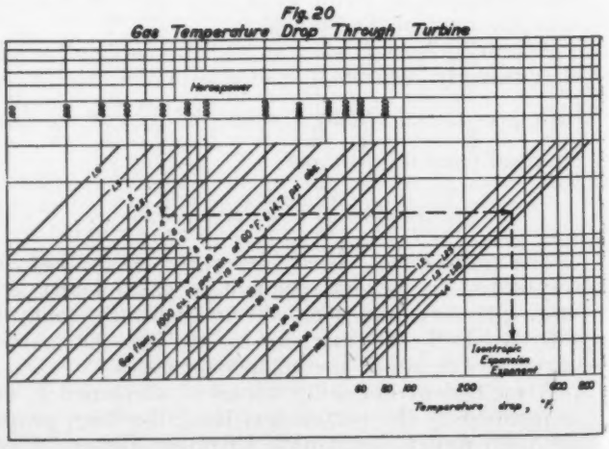
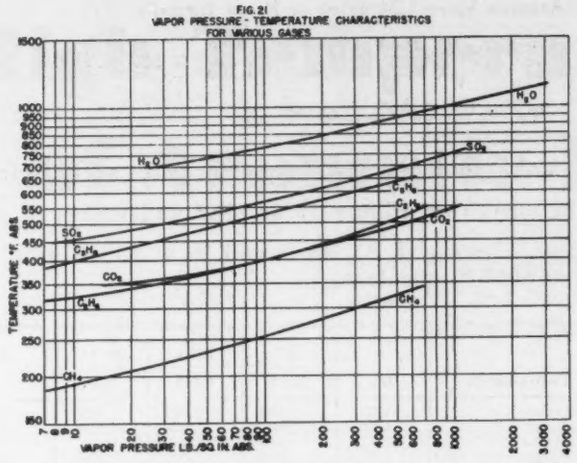


Fig. 20
Gas Temperature Drop Through Turbine





Company, Lynn, Massachusetts. It is doubtful whether the effective error due to the use of this method with actual gases is of appreciable magnitude except at extremely high pressures. No more suitable method is known to the writers. In this method

$$\text{Combined } k = \frac{\Sigma \frac{ak}{k-1}}{\Sigma \frac{a}{k-1}} \qquad (10)$$

in which a is the fractional part by volume of a component.

Changes from fractional parts by weights to fractional parts by volume and vice versa can be made by means of the following formulae

$$a = \frac{bM}{m}, b = \frac{am}{M}, M = \Sigma\,(am), \frac{1}{M} = \Sigma\left(\frac{b}{m}\right)$$

If many energy calculations will be required for a given gas mixture, it will be well to compute values of combined $\frac{pv}{T}$ and k over sufficiently wide ranges and plot up curves. This will be found much simpler than working up a Mollier Chart for the gas on a scale which will give corresponding accuracy.

The approximate temperature drop from turbine inlet to exhaust can be obtained from the monograph in Figure 20, when the horsepower corresponding to a given volume flow and isentropic expansion exponent is known.

Although the calculation method just described is derived for theoretical power outputs of superheated gases, experience with steam and mercury indicates that the supersaturation effect will prevent any serious inaccuracy in using it for calculating turbine outputs for expansions down to approximately one-half of the pressure at which the isentropic expansion crosses the saturation line or the dew line, in the case of a compound gas. The turbine efficiency used should be that based on complete superheated gas expansion. Exhaust temperatures determined from Figure 20 may, however, be incorrect in such cases. Vapor pressure curves for several gases are given in Figure 21.

The illustration in Figure 22 of the comparative physical sizes of turbines operated by several gases may be of some interest. The turbine operated by mercury is assumed to have one expansion stage. The numbers of expansion stages for the other turbines are in proportion to the available energies of their gases as compared to the available energy for the mercury. The relative number of stages is indicated by the turbine barrel length as compared with that of the mercury turbine. The comparative inlet and exhaust sizes, worked out on a consistent basis, are also shown in the illustration.

Certain useful data on various gases are tabulated in Table 1.

Summary

1. It is probable that many engineers who are associated with or considering processes in which gases are available under pressure will welcome a simple and accurate method of estimating the power output which can be obtained from a flow of gas expanding in a turbine between given pressures. Such a method is given in this paper,

2. Certain processes may be improved or operated more economically by the installation of turbines to derive power from the expansion of gases whose energy might otherwise be wasted or inefficiently used.

3. In some cases the reduction in temperature resulting from expansion through a turbine may be more important than the power obtained.

4. By expanding gases through turbines rather than wastefully through valves and small pipe lines, power can often be derived which will replace power derived from the burning of fuel and thus help to conserve fuel.

Example of the Derivation of Turbine Shaft Horsepower

		by volume (mol. fraction)
Gas Composition	Methane	.8211
	Ethane	.0753
	Propane	.0426
	Nitrogen	.0140
	Carbon Dioxide	.0470
		1.0000
Initial Pressure	75 pounds per sq. in. absolute	
Final Pressure	15 pounds per sq. in. absolute	
Initial Temperature	340° F.	
Gas Flow	8000 cu. ft. per min. at 60° F. and 14.7 lbs./in.² absolute	

1. Derivation of Output from Figure 5.

From the k_o curves on Figure 19 select by inspection an approximate mean value of isentropic exponent. The relative portions of the various component gases and the locations of the curves indicate that k_m for the combined gas will fall a little below the curve for methane. As a mean temperature we may take 100 less than the initial temperature. Since the k_o curves are plotted against absolute temperature the mean temperature will be $340° - 100° + 460° = 700°$. It would appear then that a value of 1.24 for mean k is approximately correct.

This example is shown plotted in Figure 5, and the dash lines and arrows indicate the path to be followed

Fig. 22
Comparison of Turbines Operated by Various Gases
3500 H.P. Inlet – 170° C., 1000 °F., Back Pressure – 5° C.
ASSUMPTIONS
One stage for mercury turbine.
No. of stages for other turbines proportional to available energy per lb. of gas
Barrel lengths are proportional to the number of stages
Inlet diameter based on 1% pressure drop.
Exhaust diameter based on 1% pressure drop and 70% internal efficiency
Inlet Diam. = 6.5"
Exhaust Diam. = 24.7"
Methane
Diam. = 10.3"
Diam. = 28.0"
Combustion Gas
Diam. = 8.0"
Diam. = 19.5
Superheated Steam
Diam. = 15.4"
Mercury
Diam. = 4.54"
Diam. = 5.3"
Hydrogen
Diam. = 14.6"

in working out a solution with this nomograph. The operating conditions chosen for the example, together with the efficiency assumed in the nomograph, give a turbine shaft horsepower of approximately 800.

II—Derivation of Output from the Properties of the Component Gases, the Perfect Gas Energy Formula and an Assumed Turbine Efficiency.

Component	Volume Fraction or Mol. Fraction a	Mol. Wt. m	am	Weight Fraction $b=\frac{am}{M}$
Methane	.8211	16.03	13.15	.666
Ethane	.0753	30.05	2.26	.114
Propane	.0426	44.06	1.88	.095
Nitrogen	.0140	28.02	.39	.020
Carbon Dioxide	.0470	44.00	2.07	.105
			M=19.75	1.000

Gas	Formula	Mol. Wt. M	Boiling Temp. @ 14.7#/in.² abs. °R	Critical Pressure p_c #/in.² abs.	Critical Temp. T_c °R	Theoretical $\frac{pv}{T}=R=\frac{10.72}{M}$
Air		28.97		547.0	238.5	.3701
Ammonia	NH_3	17.03	431.3	1639.0	730.0	.6295
Argon	A	39.93	157.5	706.0	272.2	.2687
Carbon Dioxide	CO_2	44.00	347.4	1073.0	548.0	.2437
Carbon Monoxide	CO	28.00	149.6	514.6	241.7	.3829
Chlorine	Cl_2	70.91	429.3	1185.0	750.8	.1512
Ethane	C_2H_6	30.05	332.9	717.5	550.0	.3568
Ethylene	C_2H_4	28.03	305.0	748.2	509.0	.3825
Helium	He	4.00	7.7	33.5	9.54	2.681
Hydrogen	H_2	2.016	36.7	188.2	59.96	5.319
Hydrogen Chloride	HCl	36.47	342.1	1199.0	584.5	.2939
Hydrogen Sulfide	H_2S	34.08	379.6	1307.0	673.3	.3147
Methane	CH_4	16.03	201.0	673.5	343.2	.6690
Mercury	Hg	200.61	1134.0			.0535
Neon	Ne	20.18	49.1	382.0	80.1	.5320
Nitric Oxide	NO	30.01	216.4	956.0	322.8	.3572
Nitrogen	N_2	28.02	138.9	492.0	226.8	.3826
Nitrous Oxide	N_2O	44.02	330.1	1054.0	557.4	.2435
Oxygen	O_2	32.00	162.4	730.8	277.8	.3350
Propane	C_3H_8	44.06	411.7	632.2	663.7	.2435
Sulfur Dioxide	SO_2	64.06	474.1	1143.0	774.6	.1674
Water	H_2O	18.02	671.6	3206.2	1164.5	.5948

Data from Smithsonian Tables, 1933.

Assume $k_m = 1.24$ as in I. From formula (7):

$$T_2 = 800\left(\frac{75}{15}\right)^{-0.1935} = \frac{800}{1.365} = 586°\text{F. abs.}$$

$$T_m = \frac{800 + 586}{2} = 693°\text{F. abs.}$$

Values of k_m for the component gases are read from the curves on Figure 19 at 693° and values of $\frac{pv}{T}$ from Figures 12, 13, 14, 8 and 10 at 75 psi absolute and 800° F. absolute.

Component	k_m	$\frac{a}{k_m-1}$	$\frac{a\,k_m}{k_m-1}$	$\frac{p_1 v_1}{T_1}$	$b\times\frac{p_1 v_1}{T_1}$
Methane	1.26	3.156	3.977	.669	.445
Ethane	1.15	.502	.578	.355	.041
Propane	1.11	.387	.430	.238	.023
Nitrogen	1.395	.035	.049	.384	.008
Carbon Dioxide	1.255	.184	.231	.243	.025
		4.264	5.265		.542

$$\text{Combined } k_m = \frac{5.265}{4.264} = 1.235$$

In Figure 15, at $k = 1.235$ and $\frac{p_1}{p_2} = 5.0$, $\frac{E}{p_1 v_1} = 0.258$

$$\text{Combined } \frac{p_1 v_1}{T_1} = .542$$

$E = .258 \times .542 \times 800 = 111.8$ Btu./pound.

The gas flow is 8000 cu. ft. per min. at 60° F. (520° F. abs.) and 14.7 psi. abs.

$$v = \frac{380}{M} = \frac{380}{19.75} = 19.23$$

$$\text{Weight flow} = \frac{8000 \times 60}{19.23} = 24{,}960 \text{ pounds per hour.}$$

$$\text{Theoretical horsepower} = \frac{24{,}960 \times 111.8}{2545} = 1096$$

Assuming a turbine effiiciency of .725, the turbine shaft horsepower is *795*.

Meaning of Symbols

- a = fractional part by volume (of a component in a mixture)
- b = fractional part by weight (of a component in a mixture)
- c_p = constant pressure specific heat, Btu./lb./° F.
- c_v = constant volume specific heat, Btu./lb./° F.
- E = available energy of isentropic expansion or compression, Btu./lb.
- e = turbine efficiency, dimensionless
- k = exponent of isentropic expansion or compression
- M = molecular weight of a pure gas or equivalent molecular weight of a gas mixture
- m = molecular weight of a component in a gas mixture
- p = pressure, lb./sq. in. abs.
- Q = gas flow, cu. ft./min. at 60° F. and 14.7 lbs./in.² abs. (i.e., free gas)
- $R = \text{gas constant} = \frac{pv}{T}$
- T = temperature, °F. abs., or °Rankine
- v = specific volume, cu. ft./lb.
- $(\ )_0$ refers to condition of gas at zero pressure
- *$(\ )_1$ refers to condition of gas before expansion or compression
- *$(\ )_2$ refers to condition of gas after expansion or compression
- $(\ )_c$ refers to condition of gas at the critical point
- $(\ )_m$ refers to mean value between $(\ )_1$ and $(\ )_2$.

* In several cases the subscripts $(\ )_1$, $(\ )_2$, etc. are used to indicate individual values for the several components of a compound gas. In these cases this is stated in the text.

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NOTE: Extrapolations of some of the preceding data have been made by means of the Beattie-Bridgman formula as given in "Industrial Chemical Calculations," by Hougen and Watson, Second Edition, John Wiley and Son.

B. SPECIFIC HEATS AT ZERO PRESSURE
(Used in calculations of isentropic expansion exponent at zero pressure.)

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High Temperature Alkylation of Aromatic Hydrocarbons

By A. N. SACHANEN and A. A. O'KELLY
Research and Development Laboratories,
Socony-Vacuum Oil Company

AROMATIC hydrocarbons, e. g., benzene and toluene, have been alkylated with olefines at high temperatures of 800° F. and above. This process can be performed under atmospheric pressure and in the absence of catalysts, but high pressures and such catalysts as activated clay improve the yields of alkyl aromatics. Toluene is more easily alkylated than benzene at these temperatures. On the other hand, propylene and butylene are stronger alkylating agents than amylene. Under high temperatures the alkyl aromatics produced were partially cracked, forming alkyl aromatics of a lower molecular weight. As a result, alkyl aromatics formed were composed of an entire series of aromatics beginning with toluene and increasing in molecular weight. The alkyl aromatics produced contained 90 percent or more of purely aromatic hydrocarbons.

This paper was delivered before the Division of Petroleum Chemistry of the American Chemical Society, Atlantic City, September 8 to 12, 1941, and printed in the December, 1941, issue of *Industrial and Engineering Chemistry*.

LOW temperature alkylation of aromatic and paraffinic hydrocarbons with olefines in the presence of acids or metal chlorides has been investigated by many experimenters[9]. Only a few references describe the high-temperature-alkylation processes.

Frey and Hepp[3] investigated the alkylation of propane and isobutane with ethylene at 500-525°C. and under pressures as high as 4500 pounds per square inch. The reaction time was 4-5 minutes. The relative amount of ethylene used was very low and the reaction took place in the presence of a large excess of a paraffinic hydrocarbon in order to minimize polymerization of the olefine. Under these conditions alkylation was the predominant reaction. With propane, the ethylene reacted to produce pentanes, and with isobutane, hexanes were formed. At the present time the high-temperature-pressure alkylation of isobutane with ethylene is being used commercially for the production of neohexane.[8]

Keith and Ward[7] described experiments on cracking gaseous paraffins and olefines at 429-453°C., (800-850°F.), and 800 pounds per square inch pressure. The yield of gasoline formed was somewhat higher than the quantity of olefines capable of being converted into polymers. Thus the authors concluded that this excessive yield over olefines present represented alkylation of paraffins. However, according to the results of Frey and Hepp[3], the pressure used in the above experiments should be considered too low for alkylation.

Blunck and Carmody[1] reported on the catalytic alkylation of paraffins with olefines in the presence of double salts of aluminum chloride such as $LiAlCl_4$, $NaAlCl_4$, etc. The temperature of the process was 154-281°C.,(310-555°F.), i.e., on the border between high- and low-temperature alkylation.

The data on high-temperature alkylation of aromatics are meager. Some I. G. Farbenind. patents[4] describe the alkylation of toluene or naphthalene with gaseous olefines at 300°C. in the presence of chromium or cerium metaphosphate. Schollkopf[11] alkylated naphthalene with ethylene at 230°C. under a pressure of 10-15 atmospheres in the presence of an activated hydrosilicate catalyst. Ipatieff and Komarewsky[5] described the alkylation of aromatics with paraffins at a temperature between 700° and 900°F.

TABLE 1
Free Energy Equations of Polymerization and Alkylation

Reaction	Free Energy
1. $C_2H_4 + C_2H_4 \rightarrow C_4H_8$	$\Delta F° = -24{,}400 + 32.0T$
2. $C_2H_4 + C_4H_{10} \rightarrow C_6H_{14}$	$\Delta F° = -20{,}200 + 32.4T$
3. $C_2H_4 + C_6H_6 \rightarrow C_6H_5(CH_3)_2$	$\Delta F° = -26{,}000 + 32.0T$

in the presence of a solid phosphoric acid catalyst. Under these conditions the paraffins decomposed and the decomposition products combined with aromatic hydrocarbons.

Thermodynamically the alkylation of aromatic hydrocarbons with olefines is possible at such comparatively high temperatures as 600°C. In Table 1 are given free energy quotations for polymerization of ethylene, alkylation of normal butane with ethylene and alkylation of benzene with ethylene[10]. The reaction of alkylation of benzene with formation of meta-xylene rather than ethylbenzene has been taken since free-energy data for this isomer only are available.

A comparison of the data of Table 1 shows that the thermodynamic probability of alkylation of aromatics is greater than that of polymerization or of alkylation of paraffins. Even at atmospheric pressure the values for free energy of alkylation of aromatics are negative up to 547°C. This indicates that alkylation of aromatics with olefines may occur at temperatures as high as 500-600°C. and under atmospheric or slightly elevated pressures.

Experimental Procedure
(Batch Operation)

This article describes the results of alkylation experiments performed with bombs, (batch process), in which the time of reaction was rather carefully controlled, as well as experiments conducted in continuous operation. The batch experiments occurred in an electrically heated stainless steel bomb of two

liters capacity furnished by American Instrument Company.

As aromatic hydrocarbons employed in the alkylation experiments, carefully redistilled benzene and toluene were used. The olefines used for the alkylation were propylene, butylene, and amylene. Most of the experiments were performed with amylene since this compound is more conveniently handled for bomb operations than the normally gaseous olefines. In continuous operations liquefied cracking-still gases containing propylene and butylenes as well as the corresponding paraffins were used.

The olefines were mixed with the aromatics usually in a molar ratio of 1:3 to minimize polymerization of the former. The temperature of the bomb experiments varied between 445 and 477°C.,(833-890°F.). The pressure, meanwhile, varied from 1000 to 3200 pounds per square inch. As a catalyst, activated clay was used principally and varied in amount by weight between 5 and 200 percent with respect to the aromatic-olefine mixture. The recovery of the liquid synthetic products, after reaction, was accepted as equal to the volume actually recovered plus 0.7 times the weight of catalyst used. Blank experiments showed that one gram of catalyst retained 0.7 cc. of the synthetic material. Thus, using this correction factor the recovery of liquid products after alkylation varied between 94-95 percent of the original charge.

After the alkylation reaction in a bomb had been completed, the latter was cooled by an electric fan and then opened after first relieving any residual pressure. The liquid material was then distilled from a flask provided with a fractionating column. The following fractions were taken:

NATURE OF FRACTION	Alkylation of Benzene	Alkylation of Toluene
1. Olefinic	up to 45° C.	up to 45° C.
2. Intermediate	45-70° C.	45-100° C.
3. Aromatic—(Benzene or toluene)	70-95° C.	100-116° C.
4. Alkyl Aromatics	95-210° C.	116-210° C.
5. Residuum	above 210° C.	above 210° C.

The initial boiling points of 95°C. for alkyl benzenes and 116°C. for alkyl toluenes insure a sufficient separation of alkyl aromatics, newly formed, from the original aromatics employed. Experiments have shown that after fraction 3 is taken in each of the above cases, the temperature rises rapidly to that corresponding with newly formed alkylation products. Redistillation of fraction 3 with an efficient column showed it to contain 3 percent of alkyl aromatics. Nevertheless, since this redistillation in each case would have required a great deal of time it was avoided. The yields, therefore, given below may be considered as below the yields actually possible of attainment as a matter of technicality. Actual maximum yields may thus be 1.5 percent higher than those submitted.

Fraction 4 contained relatively pure aromatic hydrocarbons. The specific gravity of this fraction was approximately 0.870,(60°/60°F.), and the refractive index, (60°F.), is of the order of 1.490, which figures correspond closely with those for pure aromatic hydrocarbons of this boiling range, i.e., 110-210°C.

The low values of iodine number 2 for these fractions, less than 20, and almost complete solubility in concentrated sulphuric acid, (95 percent or more), also show that the fractions in question consist of comparatively pure aromatic hydrocarbons.

High-boiling fractions, i.e., above 210°C., also have a high specific gravity, (0.870 or higher), and refractive indexes of 1.500 or greater. It is notable that the specific gravity of olefines, polymerized, boiling above 210°C. is about 0.800 and the refractive index about 1.450.[12] It is thus easily presumable that high-boiling fractions consist chiefly of alkylated aromatics some of which may have a polycyclic structure. Therefore the total amount of alkylated aromatics obtained in distillation is herein accepted as equal to the sum of fractions 4 and 5 given above. Fraction 5, (the residuum), may contain also some aromatics produced from the olefines employed which may be cyclized at high temperatures. Polycyclics such as diphenyl may result from the benzene at high temperatures.

The amount of alkyl aromatics boiling in the range of motor gasoline, i.e., up to 210°C.,(410°F), is accepted as equal to the above fraction 4.

Continuous Operation

Experiments of once-through flow, (continuous), and at atmospheric pressure were conducted in an iron tube heated in an electric furnace. Continuous alkylations at super-atmospheric pressures were carried out in an especially constructed apparatus consisting of a high-pressure pipe still of one-gallon-per-hour capacity. The reaction chamber in this apparatus consisted of a stainless-steel bomb of one liter capacity. The temperature was measured by means of a thermocouple placed in a well located inside the reaction chamber. The reagents, i.e., benzene and an olefine, were charged to a preheating coil and then to the above reaction chamber from a pressure charging tank by replacement with ethylene glycol which was pumped with a Bosch pump. The heating of the coil and the reaction chamber was by strip heaters. Figure 1 shows the preheating coil, reaction chamber, and strip heaters of the apparatus. It is to be noticed that half the heaters are located on the door of the heating case. These are exposed in the photograph. From the reaction chamber the charging stock passes to a condenser and thence to a suitable receiver, amounting to a small gas separator. A reduction valve is placed between the reaction chamber and the condenser. The separation of alkyl benzenes produced in the continuous process was performed in the same manner as described for batch operation.

Temperatures as high as 525°C.,(977°F.), and pressures up to 2000 pounds were employed in a continuous process. The reaction chamber was filled with activated clay and the process took place with a constant excess of this catalyst. The rate was such that the reaction time was approximately two minutes. The catalyst was easily regenerated after becoming inactive due to coking. Hundreds of such regenerations were possible without any noticeable decrease of the alkylating effect. This regeneration process involves removal of gums, coke, etc., from the clay by oxidation with a stream of air at temperatures of 750°F., and above. Steam was used simultaneously or alternately, to prevent too high regeneration temperatures.

A typical experiment was one in which 10 liters of benzene were mixed with 4.2 liters of liquefied cracking still gases containing 21 percent propylene and 17 percent butylenes. The mixture was processed in the pressure still at 525°C. and 1500 pounds per square inch pressure and gave about 10.5 liters of synthetic crude. After distillation of the latter, 3180 cc. of alkyl aromatics boiling from 95-150°C., of spe-

TABLE 2
Alkylation of Benzene with Amylene Under Varied Conditions

Molar Ratio Benzene to Amylene	Catalyst Percent Clay by Weight	Temperature °F.	Temperature °C.	Pressure lbs./in.²	Time in Minutes	*Percent Total Yield Alkyl Aromatics	*Percent Yield of Alkyl Benzenes Boiling to 410° F.
3:1	None	830	443	1400	90	17	10
3:1	5	845	452	1100	30	24	18
3:1	10	850	454	1300	30	34	22
3:1	25	845	452	1300	35	47	31
3:1	50	845	452	1300	30	39	26
3:1	10	845	452	1400	15	23	16
3:1	20	845	452	800	30	29	22
3:1	15	845	452	2700	30	44	32
3:1	20	845	452	2700	30	42	32
3:1	10	845	452	3200	30	40	28
3:1	200	890	477	Atmosphere	1–2	10	5

* i. e., the percent of alkyl aromatics synthesized with respect to the theoretical yield of amyl benzene.

cific gravity, 0.865, iodine number-12.0; and 1190 cc. boiling between 150 and 210°C., of specific gravity, 0.873 and iodine number-22.0 were obtained. In addition, 285 cc. of residuum, boiling above 210°C., were obtained.

The theoretical yield, (100 percent), of alkyl aromatics is calculated from the olefine used since benzene and toluene have been used in excess. Thus the theoretical yield in alkylation of benzene with amylene was calculated according to the equation for reaction:

$$C_5H_{10} + C_6H_6 \rightarrow C_6H_5 - C_5H_{11}$$

This means that even though polyalkyl and lower molecular weight benzenes may be produced by the reaction, the actual yields represent an assumption that none other than primary alkylation reactions occur. Likewise, in the employment of propylene and butylene, yield calculations were made on a basis of primary propyl- and butyl-benzenes as the end-product.

It should be recalled that the conditions of polymerization of olefines are rather close to those of alkylation, i.e., temperatures in the neighborhood of 445-477°C. and higher pressures of 1000 pounds per square inch and higher. Thus the polymerization of olefines may interfere with alkylation of aromatics and reduce the yield of the desired product. Practically, olefine polymerization does not occur to any appreciable extent in the presence of a sufficient excess of aromatics. A molar ratio, however, of 3:1, (aromatic: olefine), was found necessary to reduce polymerization products of less than 10 percent of the total yield. It is to be noted also that the free energy of alkylation of aromatics is more negative than that of polymerization of olefines, under these conditions, and hence the former may become the predominant reaction.

Alkylation Variables

Data on the alkylation of benzene an toluene with olefines are summarized in Tables 2 and 3. At 445-477° C. the rate of alkylation is satisfactorily high. The reaction time to produce 20-30 percent of alkyl aromatics of gasoline boiling range, (up to 210° C.), at these temperatures is 15-30 minutes and may be lessened by the use of a larger relative amount of catalyst.

High pressure is not necessarily a pre-requisite to thermal alkylation of aromatics. If the relative amount of activated clay is high, the rate of alkylation of benzene and especially of toluene is comparatively rapid, even under atmospheric pressure, (Tables 2 and 3). Nevertheless, moderately high pressures are very favorable to the process. Above 2400 pounds, however, increase of pressure is not of any advantage since its only effect is to produce a larger proportion of high-boiling product without contributing effectively to the increase of total yield. Data show that maximum yields of alkyl aromatics are obtained under pressures of 2400 pounds per square inch for benzene and 2100 pounds for toluene. This negative effect of higher pressures is evidently due to the formation of polyalkyl aromatics.

The relative amount of catalyst may be decreased considerably if pressures in the region of 2000 pounds per square inch are used instead of the 1000-1500 pounds generally used in these experiments.

Thermal alkylation of aromatics with olefines may be performed non-catalytically, (Tables 2 and 3), if the pressure is in the neighborhood of 1000-1500 pounds per square inch. The product, however, is colored slightly and is apparently contaminated with non-aromatic materials as shown by its specific gravity. The alkylation process is greatly accelerated by the presence of activated clay and especially influential is the latter in formation of aromatics in the gasoline boiling range. For example, in the absence of catalyst, only 11 percent of low-boiling alkyl aromatics are produced from benzene at 445°C., and 1400 pounds for a period of 90 minutes whereas 25 percent are produced in the presence of 12.5 percent clay under the same temperature-pressure conditions with a reaction time of only 20 minutes.

Non-catalytic alkylation of toluene at 477° C. and 1200-1400 pounds pressure for 15 minutes forms about 20 percent of low-boiling (to 150° C.) alkyl toluenes, whereas 40 percent are produced in the presence of 15 percent clay, other conditions being equal.

The data of Table 4 demonstrate the influence of the relative amount of catalyst on the rate of alkylation and yields. The yields and aromaticity of the aromatics formed are higher as the amount of catalyst relative to the charge is increased.

Toluene is more capable of alkylation than benzene, especially under atmospheric pressure. Other conditions being equal, toluene forms 20-30 percent of alkyl aromatics boiling up to 210° C. whereas benzene yields only 5 percent of theoretical. Under high pressures this difference between benzene and toluene is considerably diminished and benzene becomes readily alkylated, producing as high as 30 percent of gaso-

TABLE 3
Alkylation of Toluene with Amylene Under Varied Conditions

Molar Ratio Toluene to Amylene	Catalyst Percent by Weight	Temperature °F.	Temperature °C.	Pressure in lbs./in.²	Reaction Time in Minutes	*Percent Total Yield Alkyl Aromatics	*Percent Yield of Alkyl Toluenes Boiling to 410° F.
3:1	30	845	452	1250	45	65	45
3:1	11	845	452	2100	45	84	72
3:1	None	885	473	1200	15	27	19
3:1	None	885	473	1300	15	26	15
5:1	None	890	477	1400	15	35	18
3:1	None	880	471	1300	30	34	16
3:1	50	890	477	1200	15	52	46
3:1	200	890	477	Atmosphere	1–2	32	22

* i. e., the percent of alkyl aromatics synthesized with respect to the theoretical yield of amyl-toluene.

TABLE 4
Alkylation of Benzene with Amylene in the Presence of Varied Amounts of Catalyst

Temperature.....850° F. (454° C.)
Pressure.....1300 lbs./in.²
Time.....30 minutes
Molar Ratio.....3:1 (Benzene:Amylene)

Percent Catalyst by Weight	Percent Total Yield Alkyl Aromatics	*Percent Yield of Alkyl Aromatics Boiling to 410° F.	Specific Gravity of Alkyl Aromatics (60/60° F.)	Ref. Index of Alkyl Aromatics at 70° F.
50	39	26	0.858	1.4900
25	47	31	0.858	1.4883
10	35	22	0.858	1.4863
5	24	18	0.856	1.4823
None†	17	10	.....	1.4808

* i. e., the percent of alkyl aromatics synthesized with respect to the theoretical yield of amyl benzene.
† The reaction time was increased to 90 minutes.

line-boiling-range alkyl aromatics in one operation. The alkylation of toluene under high pressures converts this compound largely to quite high-boiling compounds which are of no use in aviation gasoline and of very little use in motor gasoline due to the end-boiling-point specifications of these materials.

The alkylating tendency of propylene under pressure is of about the same order as that of butylene but both exceed that of amylene, Table 5.

Under the above temperature conditions the aromatics can also be alkylated with paraffins. For instance, benzene was alkylated with pentane at 890° F. for 90 minutes in a batch operation in the presence of clay. The yield of aromatic alkylate was 40 percent by weight with respect to the pentane used. The paraffins are first cracked and resulting olefines react with the benzene.

Yields and Properties of Alkyl-Aromatics

Under the most favorable conditions the total yield of alkyl benzenes may be as high as 67 percent (all yields are by volume) and that of alkyl toluenes as high as 83 percent of theoretical in a once-through operation or batch process. The maximum yields of alkyl benzenes and toluenes boiling up to 210° C. are respectively 56 percent and 72 percent. If the process is continuous, with recycling of unreacted materials, a total yield of 86 percent of alkyl aromatics and a 75 percent yield of the latter with end boiling point of 210° C. with respect to the theoretical may be considered a rather conservative figure for conversion of propylene or butylene. These two gases are the chief olefinic constituents of refinery-cracking-still gases. If, however, these two yields are calculated from the benzene reacted, then they become 138 percent and 115 percent respectively.

Alkyl aromatics obtained by high temperature alkylation contain a series of aromatic hydrocarbons of increasing molecular weight. For instance, alkylation of benzene with amylene produces toluene, ethylbenzene, xylenes, propyl-, butyl-, and amylbenzenes and evidently a lesser amount of highly alkylated benzenes.

Apparently amylbenzene, produced initially in the alkylation of benzene with amylene is decomposed into homologues of lower molecular weight such as butylbenzene, ethylbenzene, toluene, etc.

The formation of high molecular aromatics boiling above that of amylbenzene is due in part to the further alkylation of these newly formed compounds and in addition to certain condensation reactions which usually occur under cracking conditions. Another possible explanation of the formation of low-molecular-weight aromatics is the depolymerization of amylene to the lower-molecular-weight olefines which are combined with the aromatic hydrocarbon. Actually, both processes of dealkylation and depolymerization may occur simultaneously.

Simultaneous alkylation and cracking of the side chain to form an olefine available for the alkylation of a second aromatic nucleus are the chief processes of high-temperature alkylation. While catalytic low-temperature alkylation of aromatics produces alkyl aromatics corresponding to the structure of the olefines used, at high temperatures one obtains an entire series of compounds beginning with the simplest—toluene. As an example, alkylation of benzene with amylene in the presence of sulphuric acid[6] produces mono-, di-, and tri-amylbenzene. The boiling range of this reaction product is too high for motor gasoline. On the other hand, in a high-temperature catalytic process the same reactants produce chiefly low-molecular aromatics, boiling in the range of aviation and motor gasolines.

The distillation curve of the alkyl aromatics formed in high-temperature alkylation depends upon the temperature and the time of reaction. Under quite severe conditions of the process, lighter-molecular-weight alkyl benzenes such as toluene, ethylbenzene,

TABLE 5
Alkylation of Benzene with Various Olefines

Temperature.....840-850° F. (449-454° C.)
Pressure.....1200-1600 lbs./in.²
Time.....30 minutes

OLIFINE	Percent Catalyst by Weight	*Percent Total Yield of Alkyl Aromatics by Volume	*Percent Yield of Alkyl Benzenes Boiling to 410° F. by Volume
Propylene	18	62	50
Butylene	12†	59	43
Amylene	10†	34	22
Butylene	12‡	67	53
Amylene	25	47	31

* i. e., the percent of alkyl aromatics synthesized with respect to the theoretical yield of corresponding alkyl benzene.
† Regenerated catalyst.
‡ Fresh catalyst.

and xylenes are produced in lesser amount. Figure 2 represents two distillation curves, (A.S.T.M.), of alkyl benzenes boiling up to 210°C. The compounds were formed under the same conditions of temperature and pressure but with different reaction times. Curve "A" represents 45 minutes and curve "B" 30 minutes reaction time. While only 17 percent of the hydrocarbons formed in the 30 minutes time are of low molecular weight as shown by their boiling points, (to 150°C.), when the reaction time is increased to 45 minutes, the percentage of low-boiling compounds reaches 53 percent by volume. Thus it is possible to control the reaction time and temperatures in such a way as to increase or decrease the amounts of alkyl benzenes boiling below 150°C., as well as the amount of material boiling above 210°C. The average iodine number of the alkyl aromatics synthesized and boiling up to 150°C. is 20. In other words, the average amount of olefines present is roughly 10 percent. The solubility of the alkyl aromatics in concentrated sulphuric acid is 95 percent or more, i.e., the content of pure aromatics, (by subtraction of the percentage of olefines), is close to 90 percent.

Mixtures of natural gasoline with the aviation cut

TABLE 6
Octane Numbers of Blends of Alkyl Aromatics with Natural Gasoline

Composition of Gasoline Tested	*Octane Number Clear	*Octane Number with 3 cc. T.E.L.	Calculated Octane Blending Value	Acid Heat in ° F.
1. Natural Gasoline—A.P.I. 72.9, E.P. 318° F.	65.3	84.8	....	
2. 50 percent above Gasoline plus 50 percent Alkyl Aromatics, A.P.I. 50.9	83.3	95.3	101.5	12.0
3. Natural Gasoline—A.P.I. 84.5, E.P. 224° F.	73.4	85.1	....	
4. 50 percent above Gasoline plus 50 percent Alkyl Aromatics, A.P.I. 53.1	90.8	96.8	96.6	7.0

* Octane numbers are by the Motor Method.

of alkyl aromatics prepared by mixing the two compounds in a 50:50 ratio gave the following data in Table 6 concerning octane value of the blends and also blending octane values of the alkyl aromatics.

The distillation curve of gasoline No. 4, (Table 6), conforms closely to the Army Air Corps Aviation specifications while No. 2 above contains an excess of materials boiling above 212°F.

The high-boiling or solvent cut of alkyl aromatics may be employed for improvement of octane number of motor gasolines since its octane blending value is 2-3 units higher than that of the aviation cut. On the other hand, this solvent fraction may also be employed as solvent naphtha of very high solvent power. Furthermore, cracking of this so-called solvent fraction results in lower-boiling aromatics which may be used in the aviation cut. The properties of this solvent fraction are listed below.

A.P.I. Gravity.....31.5
Boiling Range.....300-424°F.
Kauri-Butanol Number 81.8
Aniline Point .....—38°C.
Color.....Water white to very light yellow

This solvent material consists chiefly of propylbutyl-, and amylbenzenes. The total amount of unsaturates does not exceed 5 percent by volume.

Reforming Cracked Gasolines With Benzol

Destructive high-temperature alkylation of benzene with high-molecular-weight olefines found in cracked gasolines may also be performed. As a result the octane number and chemical stability of alkylated or reformed gasolines are considerably increased due to the formation of stable and high-octane alkyl benzenes. From 10 to 30 percent of benzene by volume may be used for the alkylation under previously mentioned conditions, i.e., at temperatures around 850-950°F. and at elevated pressures. The presence of activated clay is also beneficial to this process. The yield of reformed gasoline in the original boiling range is about 75 percent by volume. Table 7 gives the results of alkylation of benzene with the olefines contained in two cracked gasolines.

TABLE 7
Results of Reforming Cracked Gasolines by Alkylation

Composition of Gasoline	A.P.I. Gravity	*Octane Number Blank	*Octane Number with 3 cc. T.E.L.	Acid Heat ° F.
Liquid Phase Cracked Gasoline	57.7	66.6	78.0	Above 100
Same plus 30 percent Benzene (Before Alkylation)	48.1	72.0	82.6	Above 100
Same plus 30 percent Benzene (After Alkylation)	41.4	81.6	89.7	32
Vapor Phase Cracked Gasoline	46.8	78.5	84.0	Above 100
Same plus 30 percent Benzene (Before Alkylation)	41.8	81.0	86.4	Above 100
Same plus 30 percent Benzene (After Alkylation)	37.3	84.0	90.0	32
Same plus 15 percent Benzene (Before Alkylation)	44.7	79.5	85.0	Above 100
Same plus 15 percent Benzene (After Alkylation)	41.8	81.9	90.6	30

* Octane numbers are by the Motor Method.

The data of Table 8 show that cracked gasolines reformed with benzene by alkylation have improved octane numbers and stability. The response to tetra ethyl lead, however, is relatively poor. The chemical effect, furthermore, of reforming by alkylation is clearly shown by a comparison of the chemical composition of vapor phase cracked gasoline before and after alkylation with 30 percent benzene, below.

TABLE 8
Chemical Composition of a Vapor Phase Cracked Gasoline Before and After Alkylation with 30 Percent Benzene

Type of Compound	*Percent Cracked Gasoline	*Percent After Additon of 30 Percent Benzene	*Percent Same After Alkylation
Unsaturates	54	38	11
Aromatics	11	38	58
Naphthenes	25	17	26
Paraffins	10	7	5

* By volume.

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Spectrophotometric Characterization of Lubricating Oils

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IT WAS the purpose of the study described in the following report to develop a convenient method for the characterization of lubricating oils with the spectrophotometer, and to relate this method to the systems for characterizing oils with other instruments.

Apparatus and Materials

A Coleman Model 10-S-30 spectrophotometer was used to measure transmittances. Matched square cuvettes providing a liquid depth of 1.303 cm. were used to hold the reference liquid and oil samples. The cuvettes were cleaned with ether. The measurements were made at 24° to 26° C.

To keep transmittances below 100, Squibb's clear heavy Californian mineral oil was used as the reference liquid. Two sets of oil samples were analyzed spectrophotometrically: Texaco oils from the Texaco Beacon laboratory, and Conoco oils furnished by the Refinery Supply Company of Houston. The A.S.T.M. Union color numbers supplied with the oils were checked in this laboratory and found to be correct.

Characterization by Reference to a Fixed Transmittance

Transmittances for the oil samples were measured at 30 millimicron intervals over the spectral range from 350 to 1000 millimicrons. The Texaco oils gave the family of curves shown in Figure 1. The curves for the Conoco oils did not differ greatly from these; the extent of the agreement may be inferred from other data given below.

It appears from Figure 1 that a good means of characterizing one of these oils spectrophotometrically is by the wave length at which it has a certain transmittance, under a specified set of conditions. To find a suitable transmittance which might be assigned for this purpose, the wave lengths at which each of the oils had percentage transmittances of 15, 25, 50, and 75 were read from plotted data and collected in Table 1.

Best agreement in the wave lengths for the two sets of oils was obtained for transmittances of 15 and 25, and since the minimum error of the spectrophotometer was close to the latter value, a transmittance of 25 was selected as a good point of reference. It is thus convenient to define for purposes of characterization the *spectral number, S,* of an oil as the wave length in millimicrons at which the oil has a transmittance of 25 percent relative to Squibb's clear heavy Californian mineral oil at about 25° C. in square cuvettes providing a liquid depth of 1.303 cm., or more generally a percentage transmittance of $10^{-0.462l + 2.000}$ in cuvettes with a depth of l cm., reasonably close to 1.303 cm.

This definition provides a basis for the spectrophotometric characterization of oils by numbers comparable with the numbers based on the use of various colorimeters, but permitting finer shades of distinction. Moreover, if an instrument employing a monochromator and a stable, linear response phototube is used for such characterization errors due to variations in filters or color standards, and errors due to individual differences in judging colors, are greatly reduced.

The relation between the A.S.T.M. Union color number and the spectral number—linear for all practical purposes except for oil No. 1—is given in Table 1. The values of S in the last column of the

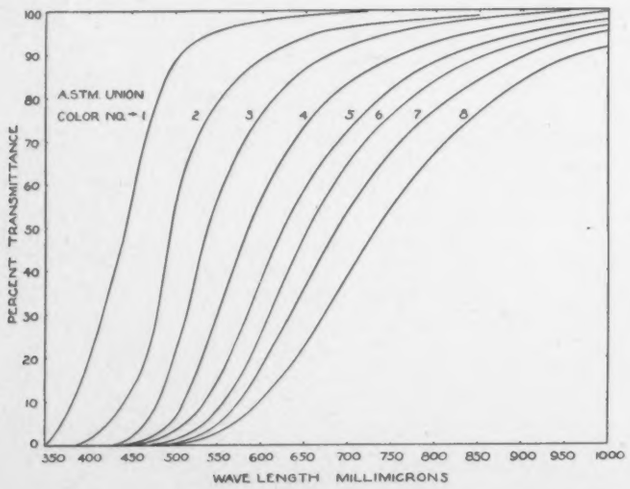

FIGURE 1
Spectral Transmittance Curves for Texaco Oils.

TABLE 1
Transmittance vs. Wave Length Data for Lubricating Oils
Wave Lengths in Millimicrons for Various Transmittances

A. S. T. M. Union Color No.	TEXACO OILS				CONOCO OILS				Spectral Number
	T: 15	25	50	75	15	25	50	75	
1.....	393	408	444	473	402	410	423	447	409
2.....	458	476	497	535	454	470	492	523	474
3.....	491	506	538	595	485	504	539	594	505
4.....	523	541	585	655	506	530	563	612	534
5.....	551	574	625	712	542	564	600	660	564
6.....	576	598	654	743	566	591	638	717	594
7.....	593	622	688	787	594	618	670	770	624
8.....	622	660	734	843	610	642	710	830	654

table were taken from a graph made by plotting the average spectral numbers for the two sets of oils studied against the corresponding A.S.T.M. Union color numbers.

Determination of the Spectral Number

The spectral number of an oil may be determined with the Coleman Model 10-S-30 spectrophotometer by reversing the usual procedure for determining transmittance at a given wave length, and finding instead the wave length S corresponding to the reference transmittance. The reference transmittance should be calculated from the exponential given above for the particular pair of matched square cuvettes used, after their depth has been measured with a micrometer and calipers.

Procedure. Place the reference liquid in one cuvette and the oil sample in the other, and set the cuvettes in the sliding carrier. Approximate S by inspection of the oil with reference to Figure 1, and set the wave-length dial at the estimated value. With the reference liquid in the light beam, set the transmittance dial at 100, and adjust the decade setting until the milliammeter deflection is zero when the contact key is tapped. Then set the transmittance dial at the calculated reference transmittance and adjust the wave-length dial until the milliammeter deflection is zero. This puts the decade out of adjustment: the final decade and wave-length dial settings must be approached by successive approximations. Put the reference liquid in the light beam, set the transmittance dial at 100, and readjust the decade setting. Again move the oil sample into the light beam, set the transmittance dial at the reference value, and shift the wave-length dial until the milliammeter gives no deflection. Continue the cycle until two successive readings give the same wave length—this is the required spectral number. The operations described above may be carried out rapidly, and more than three resettings of the wave length dial are seldom necessary.

TABLE 2
Color Analyses of Lubricating Oils

OIL	ASTM Union and NPA Color No.	Spectral Number	STANDARD TRANSMITTANCE FOR: Violet 410	Blue 460	Green 530	Yellow 580	Red 650	NPA Name
Texaco....	1	408	25	65	94	97	99	Lily White
Conoco....		409	25	81	95	98	99	
Texaco....	2	476	2	16	72	86	94	Extra Pale
Conoco....		470	1	18	79	88	94	
Texaco....	3	506	0	3	44	70	87	Lemon Pale
Conoco....		504	0	6	44	71	86	
Texaco....	4	541	0	1	19	48	74	Orange Pale
Conoco....		530	0	2	25	61	84	
Texaco....	5	574	0	0	8	28	60	Light Red
Conoco....		564	0	0	8	35	72	
Texaco....	6	598	0	0	4	17	49	Dark Red
Conoco....		591	0	0	5	20	55	
Texaco....	7	622	0	0	2	11	36	Claret Red
Conoco....		618	0	0	1	11	42	
Texaco....	8	660	0	0	1	6	22	
Conoco....		642	0	0	0	8	28	

Characterization by Transmittance of Primary Colors

When a more complete color specification is required, an oil may be described by its transmittance of visible light. Spectrophotometers such as the Coleman and Beckman instruments, which incorporate monochromators, offer a simpler, more exact, and more rational method of expressing the color of oils than any instrument using colored filters. In fact, with a spectrophotometer it is possible to describe the color of an oil fully and exactly by obtaining complete transmittance *vs* wave length curves covering the entire visible spectrum and extending into the ultra-violet and infra-red. However, such characterization is not necessary for control purposes, since the hue of an oil may be expressed with sufficient completeness in terms of a few primary colors. It seems logical to use for this purpose narrow spectral regions which are a compromise between the wave lengths best representing these primary colors and the wave lengths producing maximum visual stimulation of the corresponding color sensations. On this basis we have elected to use for purposes of color analysis 30 millimicron bands of violet, blue, green, yellow, and red light of average wave lengths 410, 460, 530, 580, and 650 millimicrons, respectively.

The color of an oil may thus be specified by its percentage transmittance T of 30 millimicron bands of light of the above average wave lengths, relative to Squibb's clear heavy Californian mineral oil as a reference liquid, in square cuvettes 1.303 cm. in depth, at a temperature of about 25° C. The transmittances may be measured rapidly with the same sample of oil and reference liquid used in determining the spectral number, by the usual direct procedure. Transmittances measured with cuvettes of any depth l cm. reasonably close to 1.303 cm. may be calculated to the standard transmittances defined above, by use of the Lambert law relation:

$$T_{\text{standard}} = 100\left(\frac{T_l}{100}\right)^{\frac{1.303}{l}} \qquad (1)$$

A special slide rule is available for this calculation.

Color analyses of the various oils studied are given in Table 2, which also relates some of the methods for describing oils. A rough idea of the net effect produced by the different combinations of colors is given by the N. P. A. semi-descriptive names. There seemed to be no point in attempting to relate monochromator color analyses with Lovibond analyses, which in our opinion should gradually be abandoned as modern instruments come into use in testing laboratories.

Acknowledgment

We are indebted to Dr. W. E. Kuhn of The Texas Company and to W. E. Schlueter of The Refinery Supply Company for their cooperation in this work, also to Dr. John Griswold of the University of Texas Chemical Engineering Department for helpful suggestions.

Summary

A convenient and exact method for the spectrophotometric characterization of lubricating oils has been proposed, and the method has been related to other methods of color description through the A.S.T.M. color numbers of two sets of oils.

Radial Temperature Gradients In Gas-Heated Tubes

L. E. STEWART*, J. B. GREEN† and R. L. HUNTINGTON‡

ALTHOUGH many industrial processes require the flow of hot gas through both open and packed tubes and cylinders, there are very little data in the literature[3,4] which give the temperature gradients from the axis to the inside wall of these tubes and vessels. It seems to be commonly accepted among many engineers that the temperature difference across the diameter of any tube or cylindrical vessel in which turbulent flow exists is of such small magnitude as to be of no practical importance. It has recently been observed, however, by Harbert et al[2] that the unsteady transfer of heat through a body of sand filled with gas is very slow. As a result of these findings, the authors have been led to investigate in a quantitative manner the radial temperature curves for several sizes of gas-heated tubes operating under steady flow conditions.

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Experimental Apparatus and Procedure

Figure 1 shows the several vertical tubes (2-, 4- and 8-inch standard pipe sizes) which were used in the studies. A diagrammatic cross sectional view of the 8-inch tube in Figure 2 gives the dimensions of the apparatus and the respective positions of the radially placed thermocouples. The thermocouples were made of copper and constantan wires which were well insulated with cotton fibre. These couples were held firmly in place by wooden inserts which were sealed into rubber stoppers. The stoppers served as fairly good insulators between the wires and the iron tube wall.

The gas which consisted of 95 percent methane,

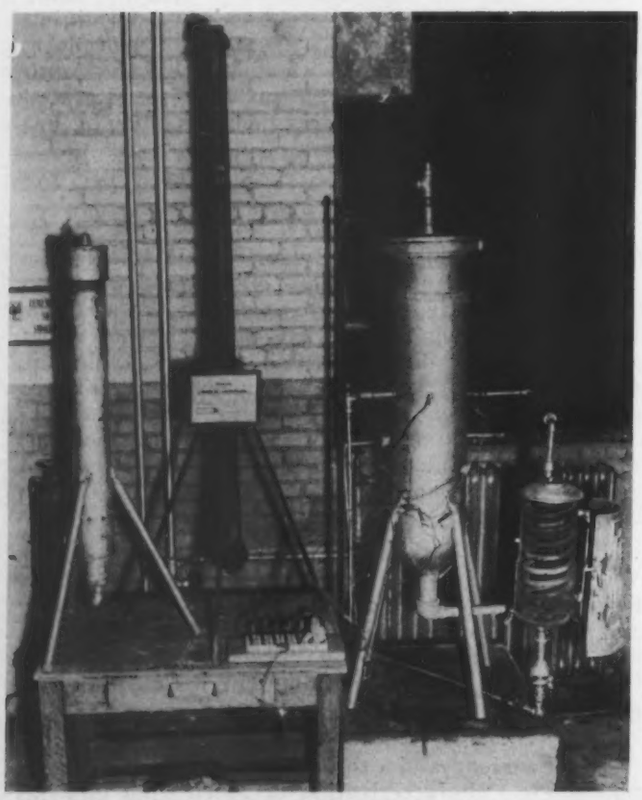

FIGURE 1
Experimental apparatus, four, two and eight-inch tubes, with larger one assembled for operation.

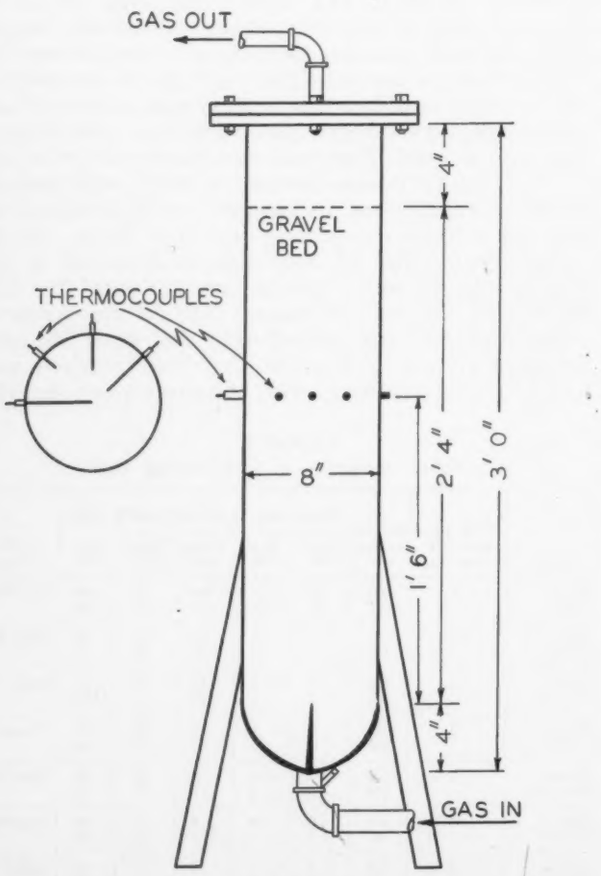

FIGURE 2
Cross sectional view of the eight-inch experimental tube, showing arrangement of radially placed thermocouples.

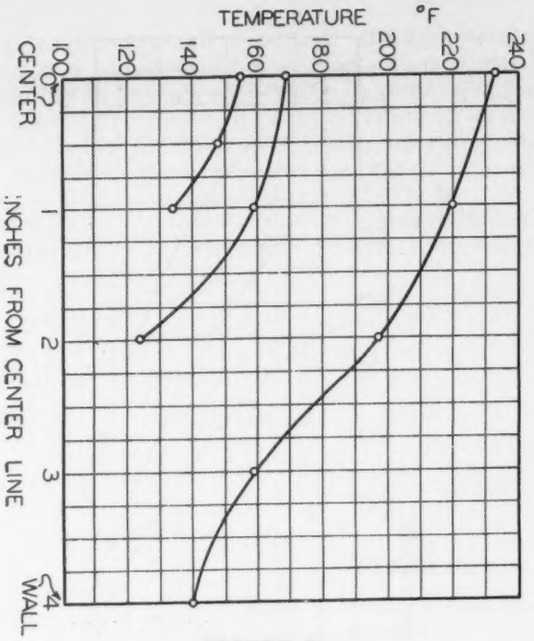

FIGURE 3

Gravel Packed Tubes 2-, 4-, and 8-Inch Diameters
Temperature Gradients
Inlet Temp. = 300° F.
Rate = 2 cu. ft./min.

Reynold's No.	Tube
5.12	2-inch
2.56	4-inch
1.28	8-inch

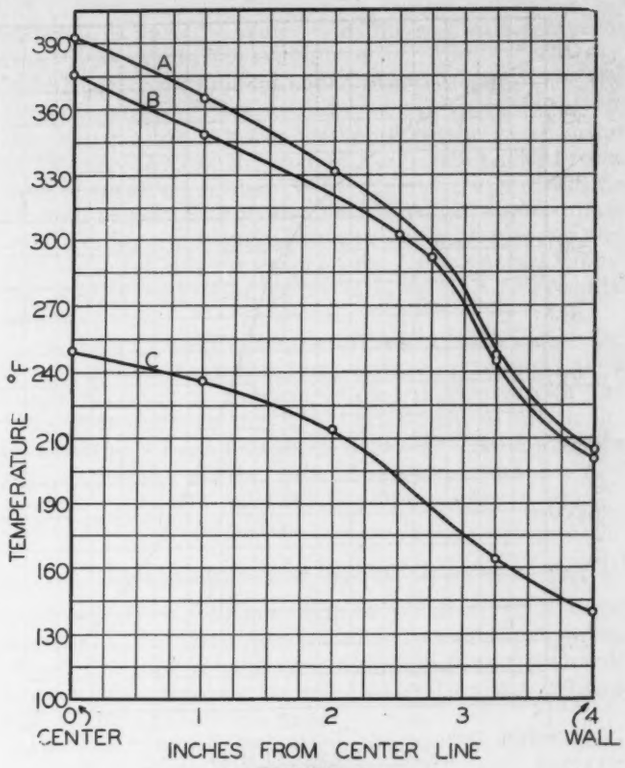

FIGURE 5

Temperature Gradients
8-Inch Gravel Packed Tube
Rate = 4 cu. ft./Min.
Reynold's No. = 10.24
Gas Inlet Temperature to Tube
Inlet Temp. △ T (Axis to Wall)
A = 528° F. — 186
B = 497° F. — 173
C = 320° F. — 110

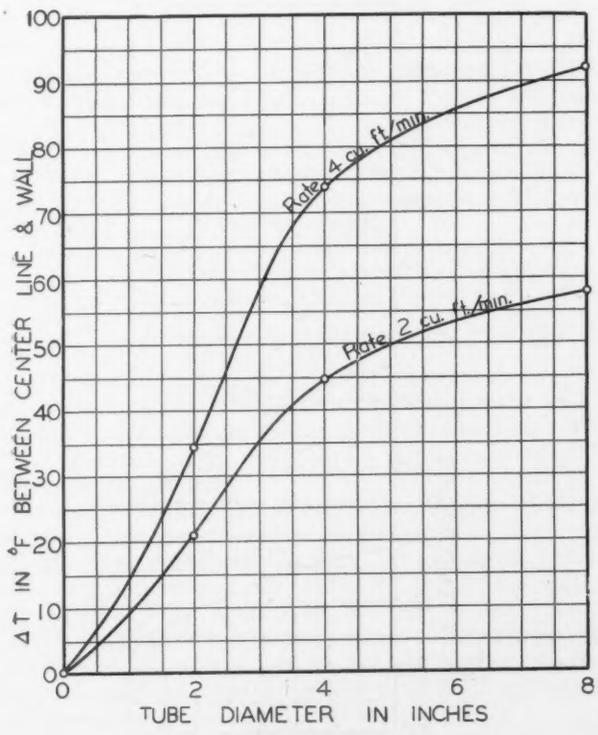

FIGURE 4

Temperature Gradients
Gravel Packed Tubes
Inlet Temp. = 300° F.

Tube Size	2 cu. ft./min.		4 cu. ft./min.
2-Inch	5.12	Reynold's Numbers	10.24
4-Inch	2.56		5.12
8-Inch	1.28		2.56

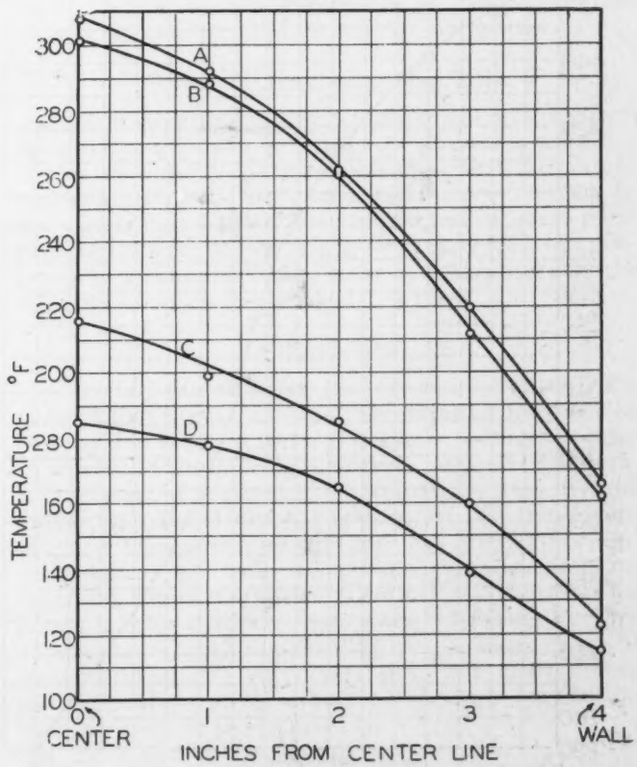

FIGURE 6

Temperature Gradient
8-Inch Empty Tube

Inlet Temp. °F.		Reynold's No.
370	A = 6 cu. ft./min.	997
370	B = 4 cu. ft./min.	663
260	C = 6 cu. ft./min.	997
260	D = 4 cu. ft./min.	663

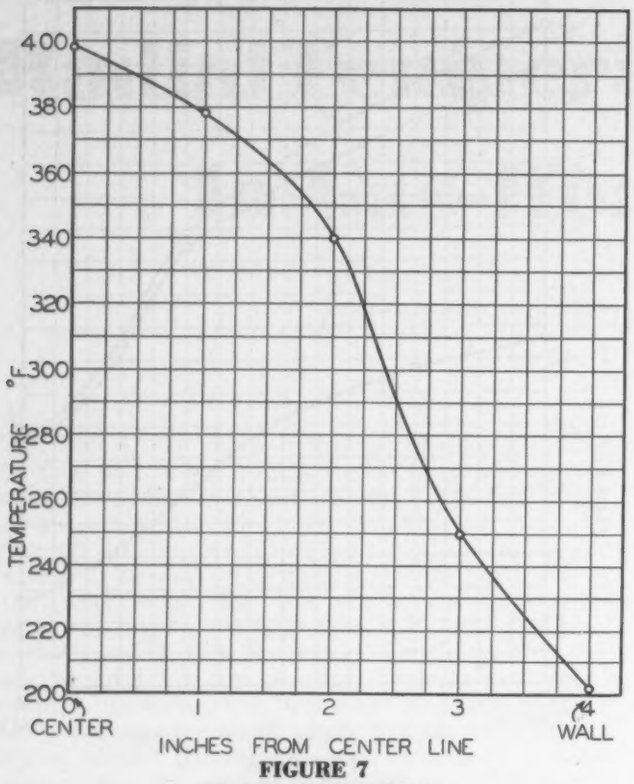

FIGURE 7

8-inch Gravel Packed Tube
Reynold's No. = 18.4
Flow Rate = 7.2 cu.ft./min.
Inlet Temp. = 443° F.
ΔT = 198° F. Center Line to Wall

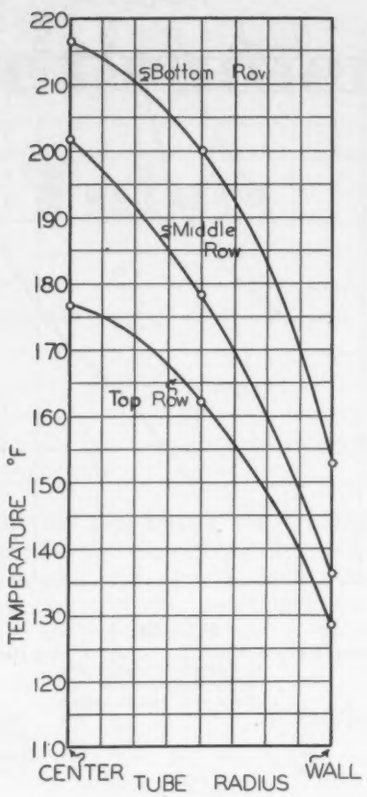

FIGURE 9

2-inch Empty Tube
Gas Inlet = 303° F.
Reynold's No. = 1326
Flow Rate = 4 cu.ft./min.

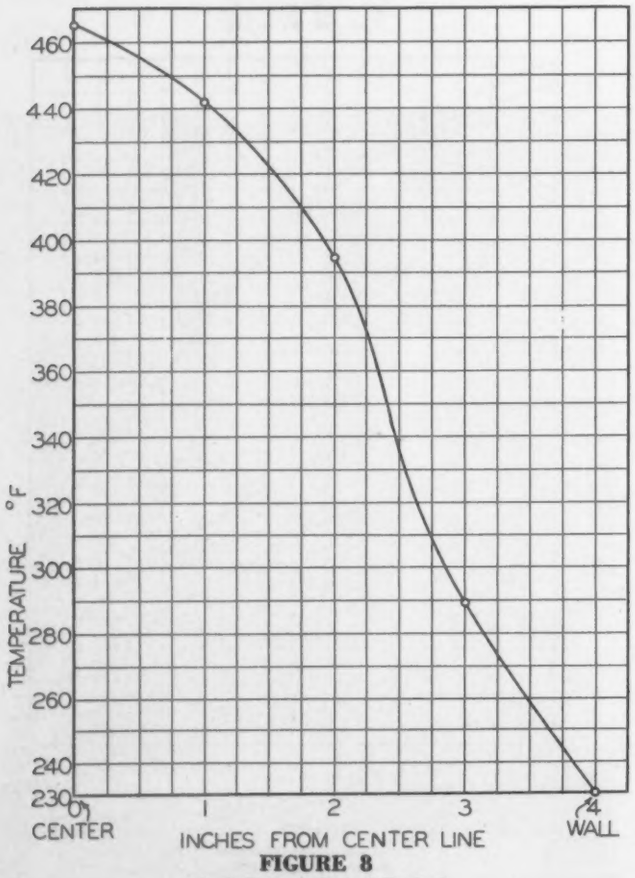

FIGURE 8

8-inch Tube — Gravel Packed
Reynold's No. = 20.5
Gas Rate = 8 cu.ft./min.
Inlet Temp. = 532° F.
ΔT = 236° F. Center line to wall

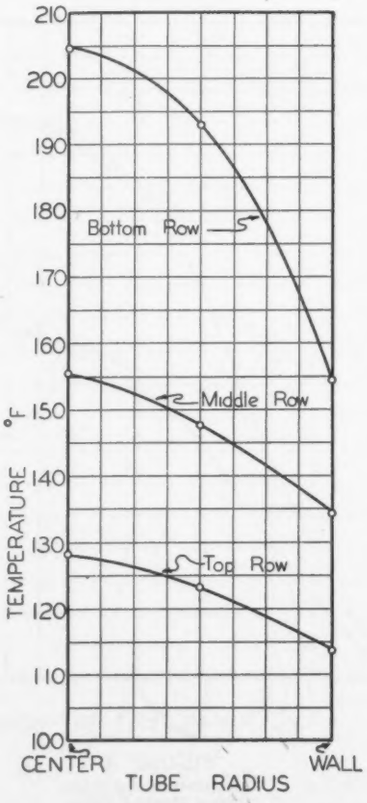

FIGURE 10

2-inch Tube Packed with Marbles .3375-inch in Diameter
Reynold's No. = 1.52
Inlet Temp. = 297° F.
Gas Rate = .60 cu.ft./min.

3 percent ethane, and 2 percent nitrogen was preheated in a copper coil before being passed into the bottom of the experimental tube. In some cases, with low rates of heat input, it required as much as 4 or 5 hours to bring the tube to a steady operating state. This was particularly true for the 8-inch tube when it was packed with flint-rock gravel.

A gas meter (accurate within ±1 percent) measured the natural gas before it was heated. Temperatures

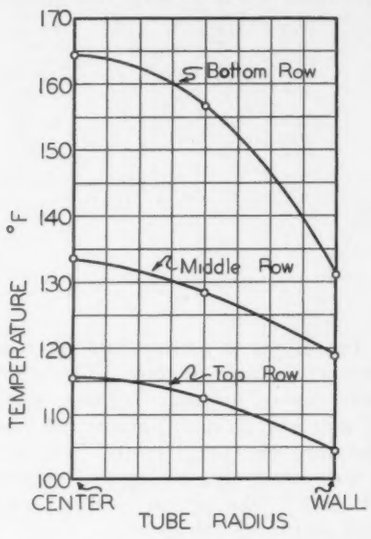

FIGURE 11

2-inch Vertical Tube
Reynold's No. = 5.12
Inlet Temp. = 223° F.
Flow Rate = 2.0 cu.ft./min.
Packed with .3375-inch diameter marbles
Porosity = 43.3%

were held within a 5° F. range at the inlet of the tube during each steady state run. The temperatures were obtained from thermocouple readings on a potentiometer.

Effect of Tube Diameter

Since commercial installations require many sizes of tubes, both packed and empty, to take care of various gas loads, several experimental tubes were studied, namely 2-, 4- and 8-inch standard pipe sizes, By holding the gas input rate at 2 standard cubic feet per minute and at an entrance temperature of 300° F., a comparison of the performance of the several tubes was readily obtained as shown in Figure 3. The Reynolds' numbers for the packed tubes were calculated on the following bases:

D = Diameter of gravel particle size in feet.
U = Linear velocity of gas in ft./sec.—free velocity through open tube divided by fractional porosity of the packing.
ρ = Density of gas in lbs. per cu. ft.
μ = Viscosity in lbs. (ft. sec.), where lbs. per foot-seconds equal (centipoises × .000672).

The Reynolds numbers for 2 cubic feet per minute gas flow ranged from 5.12 for the 2-inch tube to 1.28 for the 8-inch tube, all of which values are well within the turbulent range for porous media according to Fancher and Barnes.[1]

It was thought that an increasing degree of turbulence in the gravel pores might tend to lower the temperature difference between the gas at the central axis of the tube and the area near the inside wall of the vessel. This prediction did not prove true as shown by Figure 4. The temperature differences were more than 50 percent greater for the higher gas flow rates. Here again the flows were all well within the turbulent range for porous media.

Effect of Temperature Variation

Several experimental runs were made on the 8-inch gravel-packed tube in which all factors were held constant except the entrance temperature of the gas at the base of the vertical tube. The temperature differences varied directly with the gas inlet temperatures recorded in Figure 5.

The same relationship was found to apply in the case of the 8-inch empty tube as shown in Figure 6, the temperature differences being of the same order of magnitude as in the case of the 8-inch packed tube. The Reynolds numbers, however, were within the viscous region as 2100 is considered an approximate number[5] for the transition point between viscous and turbulent regions for empty tubes. For packed tubes[1] the similar transition point falls around (Reynolds' number) 1.0.

At higher gas-inlet temperatures in the 8-inch tube, it was found that the temperature gradient had a slight reversal of curvature toward the wall of the tube. It is believed that this variation was due to the fact that rapid conduction of heat was taking place in the iron walls of the tube. Figures 7 and 8 show these curves with tube inlet temperatures of 443° F. and 532° F., respectively.

Longitudinal and Radial Gradients

Three sets of thermocouples of three each were installed at regular spacings in the 2- and 4-inch tubes in order to find out the variation, if any, in the sharpness of the temperature gradients from the central axis to the wall of each tube.

For the empty 2-inch tube, the overall radial temperature difference did not vary much from one end of the tube to the other, as can be seen in Figure 9. For the 2-inch tube packed with marbles (.3375-inch in diameter), the temperature gradient was far more pronounced near the base of the tube due in part to the higher temperatures existing in that portion of the vessel. Figures 10 and 11 show similar results in regard to the relative magnitude of the temperature change across the tube as well as along its axis.

Effect of Insulating the Tube

Several experimental runs were made on the 4-inch tube with a 1-inch covering of magnesia asbestos. It was thought that the reduction in heat loss might make the temperature gradients less pronounced. In the range of gas velocities studied, which were comparable to those shown in the several figures, the temperature gradients proved to be about as steep as the ones obtained on the uninsulated tube.

Conclusions

Although the range of gas velocities and the size of the tubes studied in this investigation may not be comparable to conditions existing in a large amount of industrial equipment, the results indicate that careful consideration should be given such items as tube diameter, gas velocities, packing, etc., in the design of such equipment as air and gas preheaters and exchangers, as well as packed vessels such as catalytic chambers where chemical reactions are to take place at a close temperature tolerance. Further experimental work is called for over a wider range of temperatures, gas velocities, and tube sizes before the full value can be obtained through correlation with plant-scale performance.

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Sulphur Compounds in Petroleum and Its Distillates*

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THE adverse characteristics displayed by petroleum distillates containing only small amounts of sulphur and its compounds justifies all the attention that can be spared for the solution of the problems involved. This is, of course, more particularly true in regions producing so-called "sour crudes," but even the refiner processing low-sulphur crudes has much to gain by a detailed study of his crude and the distillates therefrom.

Forgetting for the moment all statutory regulations governing the maximum permissible amounts of sulphur in gasolines, and other petroleum distillates, examples may be quoted which emphasize the importance of the sulphur study. Paramount in importance is the relation of sulphur and its compounds on the effect of the addition of tetraethyl lead to gasolines. In these days of high compression ratios and higher octane number requirements it behooves the refiner to obtain the maximum response from a given dosage of tetraethyl lead.

Schultz and Buell as early as 1935 recognized the economic importance of eliminating sulphur compounds from petroleum distillates and by viewing the subject objectively did important research on the problem. Their data, some of which is quoted below, indicated the relative importance of various sulphur compounds on TEL response and graphically showed the increase in TEL susceptibility to be obtained by desulfurization of various types of gasoline.

Deductions made from their data show the relative differences between the mercaptans, sulfides, disulfides and cyclic sulphur compounds as regards TEL susceptibility. As they state, the refiner is mainly interested in saving TEL regardless of how it is done. The mere study of artificial mixtures of organic sulphur compounds and gasolines will not, in itself, effect the saving but might, by showing the way, result in methods of operation that will effect the savings so greatly desired. In Tables 1 and 2 are given Schultz and Buell's results on such artificial blends.

It is easily seen that of the several sulphur groups represented, the disulfides are the worst offenders. As these compounds are the residue of mercaptans after sweetening reactions, it is imperative that in order to conserve the maximum octane number and TEL response the mercaptans be removed insofar as is possible before the gasoline is subjected to sweetening. The methods to be used might be multiple-stage caustic washing, solutizer treatment, caustic-methanol extraction or hot-clay desulfurization. Each of these methods will be discussed.

* Before the regional meeting of The Western Petroleum Refiners Association, Wichita, Kansas, October 3, 1941.

TABLE 1
Effect of Sulfide Sulphur on Octane Numbers and TEL Response

	Weight Percent Sulphur Added	Octane Numbers, ASTM				Hebl. Suscep.
		Clear	1 cc.	2 cc.	3 cc.	
Blank	None	51.0	63.5	70.7	74.4	2.02
Methyl sulfide	.025	50.6	62.2	67.7	71.6	1.72
Methyl sulfide	.239	51.0	58.6	63.3	66.7	1.15
Ethyl sufide	.031	51.0	61.9	67.4	71.4	1.67
Ethyl sulfide	.407	50.8	56.5	60.8	64.2	0.90
so-butyl sulfide	.241	50.8	58.0	62.7	65.4	1.11
Iso-amyl sulfide	.032	50.6	60.4	66.1	69.9	1.52

Synthetic Mixtures of Organic Sulphur Compounds

For the purpose of arriving at definite conclusions a program of laboratory investigation was performed using Eastman Kodak Company organic sulphur compounds of the highest obtainable purity blended in certain preordained percentages with gasoline of essentially

TABLE 2
Effect of Disulfide Sulphur on Octane Numbers and TEL Response

	Weight Percent Sulphur Added	Octane Numbers, ASTM				Hebl. Suscep.
		Clear	1 cc.	2 cc.	3 cc.	
Blank	None	51.0	63.5	70.7	74.4	2.02
Methyl disulfide	.390	48.9	53.0	56.2	58.7	0.60
Ethyl disulfide	.022	50.6	60.2	66.2	70.3	1.55
Ethyl disulfide	.044	50.3	59.6	64.9	68.5	1.37
Ethyl disulfide	.111	50.3	57.8	61.7	64.2	0.96
Ethyl disulfide	.410	48.4	52.4	55.6	58.2	0.57
n-Butyl disulfide	.064	50.6	58.7	63.6	66.5	1.13
sec-Butyl disulfide	.028	50.3	59.6	65.8	69.5	1.48
tert-Butyl disulfide	.028	50.6	59.6	65.4	69.1	1.42
Benzyl disulfide	.034	49.3	58.8	64.6	68.4	1.45
Diphenyl disulfide	.036	49.9	59.6	66.1	69.8	1.55
Carbon disulfide	.049	51.0	61.3	67.7	71.9	1.69
Thiophene	.105	51.0	60.5	66.4	69.8	1.45

TABLE 3
Properties of Some Organic Sulphur Compounds Found in Gasolines

NAME	GRAVITY API	GRAVITY Specific	Boiling Point ° F.	Color	Odor
Mercaptans:					
Methyl	31.5	0.868	46	Colorless	Offensive
Ethyl	37.0	0.840	94	Colorless	Offensive
n-Propyl	37.8	0.8356	154	Colorless	Offensive
i-Propyl	44.2	0.8055	140	Colorless	Offensive
n-Butyl	37.7	0.8365	208	Colorless	Offensive
i-Butyl	37.8	0.8357	190	Colorless	Offensive
n-Amyl	33.6	0.857	259	Colorless	Offensive
i-Amyl	38.0	0.835	246	Colorless	Offensive
Benzyl	2.2	1.058	383	Colorless	Offensive
Sulfides:					
Methyl	35.8	0.8458	100	Colorless	Offensive
Ethyl	37.6	0.837	198	Colorless	Offensive
n-Propyl	42.3	0.814	286	Colorless	Mildly Offensive
i-Propyl	.....	.....	249	Colorless	Mildly Offensive
n-Butyl	37.2	0.839	360	Colorless	Mildly Offensive
i-Butyl	37.1	0.8386	343	Colorless	Mildly Offensive
n-Amyl	.....	.....	.....	Colorless	Inoffensive
i-Amyl	36.3	0.8431	410	Colorless	Inoffensive
Benzyl	0.6	1.0712	120 (MP)	Colorless	Inoffensive
Phenyl	—5.3	1.1185	565	Colorless	Inoffensiv
Thiophene	—1.5	1.0884	183	Colorless	Inoffensive
Disulfides:					
Methyl	2.4	1.057	243	Colorless	Mildly Offensive
Ethyl	11.0	0.993	308	Colorless	Inoffensive
n-Propyl	.....	.....	377	Colorless	Inoffensive
i-Propyl	.....	.....	.....	Colorless	Inoffensive
n-Butyl	.....	.....	212 (15 mm)	Colorless	Inoffensive
i-Butyl	.....	.....	183 (10 mm)	Colorless	Inoffensive
n-Amyl	.....	.....	264 (12 mm)	Colorless	Inoffensive
i-Amyl	22.6	0.918	482	Colorless	Inoffensive
Benzyl	.....	.....	160 (MP)	Colorless	Inoffensive
Phenyl	.....	.....	142 (MP)	Colorless	Inoffensive

Sulphur Free Gasoline Used as Base Stock for Synthetic Blends

Gravity	58.3
Color	30
IBP	118° F.
10 percent	179° F.
20 percent	204° F.
50 percent	262° F.
90 percent	360° F.
EP	405° F.
Recovery	99 percent
Doctor	Negative
Corrosion	OK
Reid Vapor Pressure	1.5 pounds
Octane, M.M.	50.0
Plus 1 cc. TEL	63.5
2 cc. TEL	69.6
3 cc. TEL	73.8

TABLE 3-A
Results of Four Hour Exposure to Sunlight on Blends of Various Sulphur Compounds, Unleaded Material

	Percent Sulphur	SAYBOLT COLORS Sulfides	SAYBOLT COLORS Disulfides
Methyl	.01	30	30
	.03	30	30
	.05	30	30
Ethyl	.01	30	30
	.03	30	30
	.05	30	27
n-Propyl	.01	30	30
	.03	30	30
	.05	30	30
n-Butyl	.01	30	30
	.03	30	30
	.05	30	30
i-Butyl	.01	30	30
	.03	30	30
	.05	30	30
n-Amyl	.01	30	30
	.03	30	30
	.05	30	28
i-Amyl	.01	30	30
	.03	30	30
	.05	30	27
Benzyl	.01	30	30
	.03	30	30
	.05	30	30
Phenyl	.01	30	23
	.03	30	10
	.05	30	—2
Thiophene	.01	30	..
	.03	30	..
	.05	30	..

no sulphur content. Attached tables delineate the various sulphur compounds used and the properties of the mixtures which were under investigation. Each sulphur compound was inspected individually and the properties of each appear in Table 3. It has not been proved to the author's entire satisfaction that each sulphur compound listed here appears in any or all gasolines but it goes without saying that if they were present the results should approximate the findings on the mixtures.

In Tables 3-A and 3-B appear data showing the relative effects of varying amounts of the different sulphur compounds on the clear and leaded octanes of the blends and sunlight stability on the unleaded blends. It appears that the first small increment of added sulphur affects the clear octane numbers to the greatest degree and that five times this amount makes no appreciable reduction in the octane number. However, the situation is far different as regards the response to TEL addition and this is clearly shown in the data. From the data of this investigation it appears that no large difference can be noted between the effects of sulfides and disulfides below the C-5 group but for the i-amyl disulfide the break appears to widen. The cyclic disulfides are by far the worst offenders as indicated by this data.

It was not thought feasible to include in this investigation analyses on percentages of the individual sulphur compound blends higher than 0.05 due to the fact that it is extremely unlikely that such would be met in actual gasolines. It might also be noted that no great difference was noted in the iso and normal sulfide blends. No marked difference appeared in the iso and normal butyl disulfide blends but did show up markedly with the C-5 disulfides as pointed out above.

It is interesting to note the extreme increase in boiling point of the corresponding mercaptans and disulfides. Methyl mercaptan boiling at 46° F. when sweetened converts to the disulfide boiling at 243° F. or well up into the gasoline boiling range. It may well be that it is this large increase in boiling points of the converted mercaptans that gives rise to bad distillation flask corrosions on technical naphthas. Normal propyl mercaptan boiling at 154° F. will be partially retained in light solvent naphthas and after sweetening may become a residue in the distillation flask, with its disulfide boiling point of 377° F. At dry point temperatures this

TABLE 3-B
Octane Numbers (M.M.) of Synthetic Sulphur Blends

TEL Content, cc. per Gallon	Percent Sulphur	Sulfides Clear	Sulfides 1 cc.	Sulfides 3 cc.	Disulfides Clear	Disulfides 1 cc.	Disulfides 3 cc.
Methyl	.01	48.8	62.2	72.7	48.7	62.7	73.9
	.03	48.6	61.7	71.7	48.6	61.4	71.6
	.05	48.4	61.2	70.2	48.4	60.5	69.8
Ethyl	.01	49.0	62.8	72.6	49.4	62.9	73.9
	.03	48.4	62.4	71.8	49.0	61.8	72.0
	.05	48.3	61.8	71.0	48.6	60.9	70.4
n-Propyl	.01	48.8	62.9	72.6	48.9	62.8	74.1
	.03	48.3	62.0	71.5	48.6	62.0	72.0
	.05	48.2	61.4	70.7	48.5	61.0	70.2
n-Butyl	.01	49.2	62.0	72.4	48.8	62.6	74.1
	.03	48.9	61.7	71.5	48.5	61.7	73.1
	.05	48.6	61.4	71.3	48.4	60.5	72.3
i-Butyl	.01	48.9	61.9	72.7	49.1	62.4	74.0
	.03	48.7	61.6	71.5	49.0	61.8	73.4
	.05	48.6	61.5	71.2	48.9	61.1	72.6
n-Amyl	.01	48.6	61.7	72.6	48.9	62.4	74.1
	.03	48.3	61.6	72.3	48.8	61.9	73.1
	.05	48.1	61.5	71.5	48.8	61.1	72.1
i-Amyl	.01	48.5	62.1	72.8	48.5	61.9	71.4
	.03	48.4	61.5	72.0	48.4	60.6	70.2
	.05	48.0	61.5	71.7	48.3	59.8	69.4
Benzyl	.01	48.5	62.2	73.0	48.2	62.3	71.6
	.03	48.1	61.7	72.2	48.0	60.8	70.7
	.05	48.0	61.1	71.7	48.0	60.0	69.7
Phenyl	.01	48.9	61.8	73.1	48.2	61.9	71.6
	.03	48.3	61.5	72.3	48.2	60.9	70.9
	.05	48.1	61.3	71.4	48.0	60.2	69.5
Thiophene	.01	49.0	62.4	72.1	....	....	....
	.03	48.7	62.3	71.5	....	....	....
	.05	48.7	62.1	71.2	....	....	....

TABLE 4
Sulphur Content of Various Crude Oils and Gasolines Therefrom

	Sulphur Content, Percent by Weight		
	Crude	Straight Run	Cracked
Mid Continent (Kansas)	.30	.035	.065
Mid Continent (Oklahoma)	.20	.010	.040
Pennsylvania	.04	.005	.020
East Texas	.30	.010	.040
Panhandle Texas	.50	.055	.210
Gulf Coast, Placedo	.15	.020	.080
California, Huntington Beach	1.30	.170	.800
California, Santa Fe Springs	.40	.050	.200
Arkansas, Smackover	2.00	.040	.190
Illinois	.25	.030	.050
Mexico, Panuco	5.20	.060	1.400
Mexico, Poza Rica	1.80	.050	.800
Venesuela, La Rosa	1.80	.070	.700
West Texas, Yoakum County	1.90	.300	.530
West Texas, Howard-Glasscock	1.48	.170	.260
Central Texas, Young County	.15	Trace	.030
Michigan	1.50	.870	....

material will crack to yield volatile sulphur compounds that discolor copper avidly.

Economies of Sulphur Reduction:

I realize that this paper is presented in an unappropriate region as regards sulphur reduction in general. In other sections of the United States where higher sulphur crudes are produced, the problem is immediate and important. Probably some of the data presented below will never hold true for Mid-Continent material but it does apply especially to West Texas, New Mexico, Arkansas, Michigan and other regions producing crudes that contain sufficient sulphur compounds to affect the properties of the distillates produced therefrom. Table 4 indicates sulphur contents of straight-run and cracked gasolines produced from various American crudes.

In many cases, regardless of statutory regulations, it is economically justifiable to remove as much sulphur as possible from petroleum distillates. This is especially true in respect to gasolines, technical naphthas and kerosenes. Sulphur should be removed from gasolines due to the increased TEL susceptibility and general overall stability. It should be removed from technical naphthas in order to improve the strict corrosion tests required of such products, and should be removed from kerosenes to improve burning characteristics.

There are several methods of accomplishing the removal of some of the sulphur types involved; each is fairly costly to operate per unit of sulphur removed and each has its advantages and disadvantages. To list several:

1. Multi-stage caustic wash
2. Solutizer treatment
3. Caustic-methanol extraction
4. Hot-clay treatment and its variations
5. Sulfuric acid treatment.

Of the five listed, the first three remove only mercaptans but operate effectively on both straight-run and cracked products. The fourth, hot-clay, does an effective job on straight-run products but due to slight polymerization is limited in its application to cracked gasolines. Also, cyclic sulphur compounds are relatively unattacked by the hot-clay method, but mercaptans, sulfides and disulfides are decomposed to great extent.

Probably the most effective overall sulphur-removal agent is sulfuric acid but there again serious faults are present. In acid treating any material containing olefinic hydrocarbons a large amount of polymerization takes place, producing polymers that must be removed by redistillation. However, acid treatment does remove some of the cyclic sulphur compounds and practically all high-sulphur California gasoline is so treated, if treated at all for sulphur reduction. To remove sulphur in worthwhile quantities from petroleum distillates, relatively large quantities of acid are required, sometimes as high as 25 to 40 pounds per barrel on high-sulphur-bearing gasolines. Initial octane loss is suffered by polymerization of the cracked components but oftentimes the overall lead response is increased to the extent that this loss is minimized to a large extent.

No attempt will be made here to evaluate the costs of installation of any of the desulfurization treatments previously mentioned. Considerable investment is required for each and all cannot be compared on the same basis due to the following facts:

The multi-stage caustic wash, solutizer treatment and caustic-methanol methods do not remove more than mercaptans, hence their usefulness in overall sulphur reduction is limited. This by no means belittles any of them for the purpose for which they are intended—all are excellent processes.

The hot-clay method and its variations are usually applicable to straight-run desulfurization and by this token limited in application.

Acid treatment, the most flexible method, suffers from comparison to the others due to its high initial investment coupled with its high operating costs.

So, for the above sketchily mentioned reasons, it was deemed advisable to omit installation and operating costs.

To look at the other side of the picture, the returns from desulfurization, are more pleasant and also more nearly supported by direct evidence that is easily confirmed in any laboratory. In Table 5 is shown the data derived from the application of several of the above mentioned desulfurization methods as applied to West Texas, Yoakum County straight-run gasoline.

It can be clearly seen from the foregoing data that the hot-clay method's savings of TEL will justify considerable thought when desulfurizing a gasoline of the type used in this illustration. The arbitrary level of 67.0 was used as a reference point because it is a level frequently leaded to in the U. S. Motor class. It would be meaningless to choose a higher level as the maximum

TABLE 5

	None	3-Stage Caustic Wash and Doctor Treatment	3-Stage Solutiser Wash and Doctor Treatment	3-Stage Caustic Methanol Wash and Doctor Treatment	Cosden Clay Treat 700° F. 20 Psi 1 S.V. NaOH Sweetened
Mercaptan sulphur, percent:					
Raw	.128	.128	.128	.128	.128
After high temperature clay treatment	....	....	....	....	.002
After first stage	....	.084	.021	.049	.000
After second stage	....	.077	.018	.020	....
After third stage	....	.071	.017	.017	....
Total sulphur, percent	.300	.280	.210	.230	.050
Color, Saybolt	30	30	28	27	25
Bromine number	2	....	....	....	2
Copper dish gum, mg.	8	8	13	10	2
Octane number, MM	54.0	53.0	53.0	53.0	56.5
Plus 1 cc. TEL/gal.	61.0	60.0	61.5	60.5	67.0
Plus 2 cc. TEL/gal.	64.5	63.7	65.2	64.2	72.0
Plus 3 cc. TEL/gal.	67.0	66.0	68.0	67.0	75.0
Reid vapor pressure	5.0	4.9	4.7	4.6	4.5
A.P.I. gravity	57.5	57.4	57.4	57.4	57.4
I.B.P., ° F.	120	116	121	124	122
5 percent	156	152	158	158	160
10 percent	171	167	174	176	174
50 percent	250	249	252	251	248
90 percent	339	341	344	343	339
95 percent	363	368	369	367	364
E.P.	396	395	396	396	383
Mercaptan reduction percent before doctor treatment	....	44.5	86.7	86.7	100
Total sulphur reduction	....	6.7	30.0	23.3	83.4
TEL, cc./gal. saving to 67 MM ON	....	Neg.	0.2	None	2.0
Monetary savings per 1000 barrels gasoline	....	....	$16.80	....	$168.00

TABLE 6

Catalytic Desulphurization of West Texas Aviation Base Stock

	Undesulphurized	Desulphurized
Gravity, A.P.I.	61.1	60.6
I.B.P.	112° F.	115° F.
10 percent	166° F.	168° F.
50 percent	212° F.	216° F.
90 percent	266° F.	269° F.
E.P.	316° F.	319° F.
Recovery	98 percent	98 percent
Color	30	30
Sulphur	0.080 percent	0.015 percent
Octane number, CFR MM	67.0	68.5
Plus 1 cc. TEL	75.8	79.0
Plus 2 cc. TEL	79.6	83.4
Plus 3 cc. TEL	81.8	86.2
Plus 4½ cc. TEL	84.0	88.7
Plus 6 cc. TEL	85.1	90.1
ASTM gum	None	None
Copper dish gum	None	None
Induction period	8 hours +	8 hours +
Susceptibility (Hebl., et al)	1.37	1.93

TEL concentration is exceeded in all cases except the hot-clay when leading to contemporary "Q" octane requirements.

Another economic factor brought out by the above illustration is the importance of the diversion of this gasoline to housebrand quality if hot-clay treated. This would amount to the price differential between the 67-octane grade on one hand and the 72-74 grade on the other. The amount realized should be at least ⅜-cent per gallon or $162.75 per 1000 barrels of gasoline. This appreciable savings, either in TEL or increase in grading, will offset quite a large installation and operating investment and should be considered when running high-sulphur straight-run gasolines into leaded gasoline channels.

In the preceding illustration the extraction processes did not show up especially well as regards overall sulphur reduction and reduction in TEL requirements, but as mentioned previously, this is only one gasoline and straight-run at that. Field shows the benefits to be gained by treating Michigan cracked gasoline with the caustic-methanol extraction process. No significant change was noted in the clear octane numbers but at the 3 cc. level the improvement was marked. The susceptibility factor increased from 0.75 to 1.04, a notable improvement. Other data from this article indicate similar results are to be obtained on widely differing gasolines.

Caustic scrubbing to remove mercaptans has been developed to high degree by the incorporation of efficient contact scrubbing and stripping towers. In one installation utilizing counter-current caustic scrubbing of cracked gasoline in which towers packed with 1½-inch carbon Raschig rings are used, from 80 to 90 percent mercaptan removal is effected in a single stage. The mercaptan scrubbing tower contains a bed of these carbon rings approximately 30 feet deep and only 15 percent by volume of 18-baumé caustic is circulated to effect the removal cited above. In this installation the original mercaptan content varied from 0.145 to 0.155 percent and the scrubbed gasoline contains only 0.015 to 0.030 percent residual mercaptan. This caustic scrubber has greatly lessened the load on the doctor-treating plant, as can be easily seen, and has more than justified its installation expense and current operating cost by reducing the amount of litharge that needs to be regenerated in the doctor-recovery system. Other refineries, according to authoritative information, are obtaining comparable results.

During the present national emergency, aviation gasoline is very much in demand and all methods to produce it should be studied with intense interest. Many straight-run gasolines produced from naphthenic and/or high sulphur crudes possess high initial octane ratings but unfortunately many times low susceptibility to the addition of tetraethyl lead. If this susceptibility could be stepped up to the point where these straight-run stocks could become vital blending agents for the production of aviation fuels, a great increase in aviation gasoline volume would result. It is possible to do this and has been definitely proved in the laboratory and plant that if these straight-run gasolines are freed of their deleterious sulphur content they may be used as aviation base or blending stocks. The sulphur may be removed by either of two existing methods, sulfuric acid or hot-clay treatment. A well-known West Texas refiner is producing such a blending stock by acid treatment and it is reported that he is treating with 15 pounds per barrel fuming sulfuric acid. No data is available to the writer regarding the results being obtained.

Hot-clay treatment was applied, however, to similar stock in the author's laboratory and the following data procured, as shown in Table 6.

The hot-clay method constantly referred to in this paper resembles the Perco bauxite desulfurization treating method in many of its mechanical respects, but is a process covered by Letters Patent issued to Gray Processes Corporation.

Data delivered before the 1940 Regional Technical Meeting of the Western Petroleum Refiners Association indicated the results to be obtained by the use of the Perco method employing bauxite as a catalyst. The results were startling and considerable improvement in tetraethyl lead susceptibilities was indicated by the use of the process. It is not necessary to review the data presented by Dr. M. W. Conn as you are all familiar with it.

To summarize results of various types of desulfurization treatments, a 430-end-point West Texas straight-run gasoline was treated by several different methods. In order to determine the classes of sulphur compounds acted upon by the various treating agents, complete sulphur analyses were made according to various classifications. This data is shown in Table 7. It will be noted that no improvement is to be gained by going to excessively high temperatures with the hot-clay treatment. It was found that incomplete removal of the mercaptans was obtained with the alcoholic plumbite solution and notes are made on the data with regard to this fact.

TABLE 7

Straight Run 430 End Point Howard-Glasscock Gasoline

	Sour	Doctor Treated	Hot Clay Treatment			Acid Treated 10 Pounds Per Barrel
			600° F.	650° F.	700° F.	
Gravity	55.6	53.4	53.5	53.4	53.4	53.7
Color	30	30	30	30	30	30
I.B.P.	134° F.	138° F.	140° F.	138° F.	141° F.	134° F.
10 percent	192° F.	194° F.	194° F.	195° F.	196° F.	190° F.
20 percent	214° F.	218° F.	215° F.	216° F.	220° F.	216° F.
30 percent	230° F.	235° F.	230° F.	234° F.	236° F.	234° F.
50 percent	264° F.	267° F.	264° F.	267° F.	265° F.	265° F.
70 percent	291° F.	300° F.	295° F.	296° F.	300° F.	300° F.
90 percent	360° F.	358° F.	356° F.	364° F.	366° F.	357° F.
E.P.	430° F.	426° F.	430° F.	435° F.	446° F.	428° F.
Recovery, percent	99	99	99	99	99	99
Octane	57.3	57.2	58.9	58.4	57.8	58.3
1 cc.	63.2	63.6	67.2	67.0	66.7	65.3
2 cc.	67.7	68.2	72.7	72.5	72.4	70.0
3 cc.	70.7	71.3	76.2	76.2	76.2	73.7
Total sulphur, percent	.2140	.160	.049	.053	.077	.080
H_2S	.0360	....	....	....	....	....
Element S.	.0180	.006	.002	.000	.007	....
Mercaptan	.0440*	....	.000	.000	.000	.025*
Di-sulphides	.0390*	.077	.000	.005	.004	.023*
Sulphides	.0770	.076	.047	.048	.060	.025
Residual S.	.0000	.001	.000	.000	.006	.007

* Incomplete removal by alcoholic plumbite.

Straight-Line Fractionation

FRACTIONATION and treating are combined in one series of operations for straight-line finishing of all products in the Salem, Illinois, plant of Warren Petroleum Corporation.

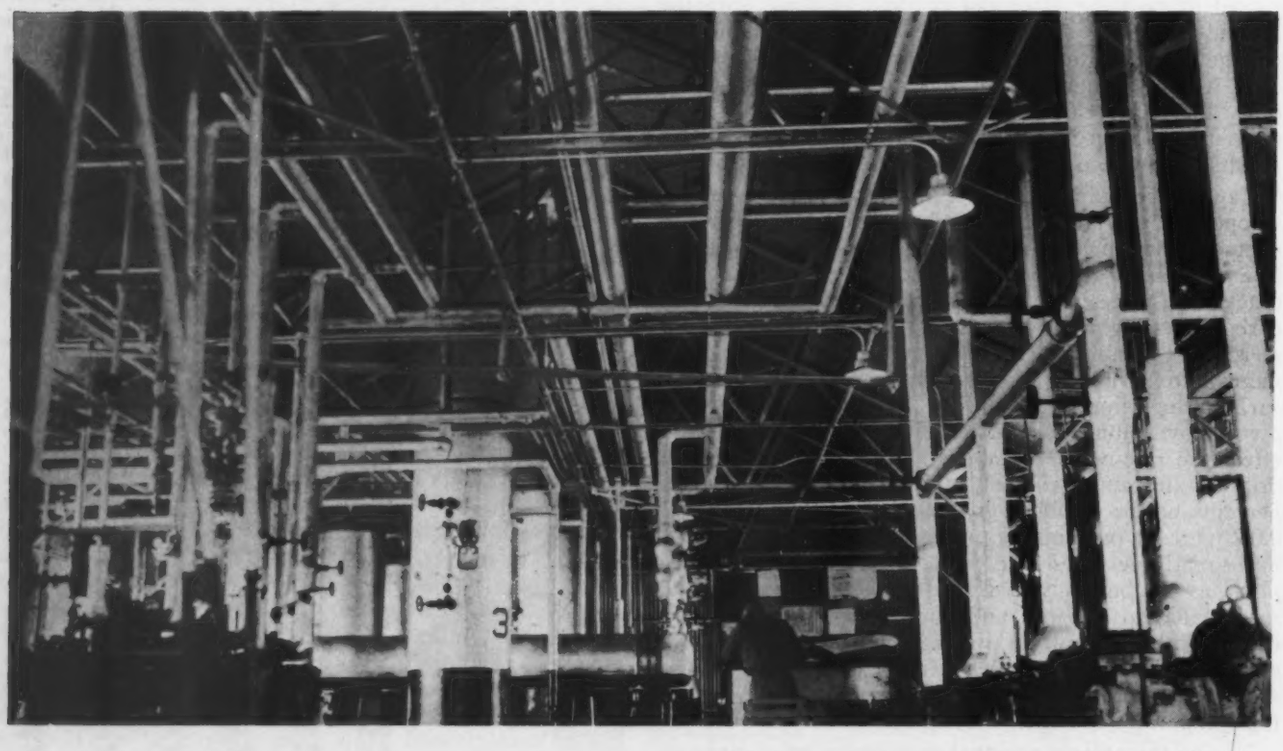
Five columns following the steam distillation equipment are operated to de-ethanize and remove hydrogen sulfide, manufacture and dry propane, separate iso-butane from normal butane and produce natural gasoline to specifications. Immediately following the column employed for removing ethane and reducing hydrogen sulfide content is a caustic contactor to complete the removal of H_2S. A horizontal caustic settler is next in line followed by a vertical vessel filled with standard grades of sand to dry the gasoline and prevent passage of entrained treating solution to the sweetener. The sweetener is the type which makes use of cupric chloride carried in a bed of fullers earth to convert the mercaptans to disulfides. The gasoline-treating system is stepped into the straight-line process following the de-ethanizing column so that the gross product is sweetened in a single operation, instead of treating each product separately.

Gas from the several formations in the Salem field has a composition which makes possible the manufacture of many cuts, ranging from propane through iso- and n-butane in quantities, to pentane and heavier. In contrast to fields elsewhere when the reflux disappears if the fractionators are adjusted to manufacture 26-pound RVP finished gasoline, the raw condensate from the distillation system at Salem contains adequate quantities of the butanes and lower-boiling fractions so that any grade of natural gasoline can be manufactured, plus a substantial quantity of iso-butane and liquified gases as desired.

With five, 400-horsepower gas-engine-driven compressors, 15,000,000 cubic feet of field gas can be processed from a compressor intake of 9 inches vacuum to an absorber pressure of 40 psi discharge. In this cycle, gas from the six oil sands is mixed indiscriminately in the gathering system.

Gas from the compressors passes through atmospheric coolers in a louvre tower in one side of the plant yard to the absorbers, two of which are used in parallel for contact with the mineral-seal absorption oil at a ratio of 40 gallons per 1000 cubic feet. Two sets of absorption-oil circulating pumps are used, one to circulate lean oil through the absorbers, the other to boost pressure to the distillation column, which is operated at 50 pounds.

All gas produced at Salem is not sour, but because of field practices, segregation is impractical. Raw gasoline in the condensate accumulator contains ap-



Interior of Warren Petroleum Company's control room in its gasoline plant at Salem, Illinois, showing arrangement of piping, pumps and other accessories in relation to fractionators.

proximately 200 grains of H_2S for each 100 cubic feet of vapor.

The first processing step, after accumulation from the vapor condensers, is to pump total condensate to the first fractionator. This tower is operated at 275 pounds pressure and the reboiler maintained at 240° F. Overhead vapors are partially condensed in quantities sufficient for reflux which is returned to the top plate.

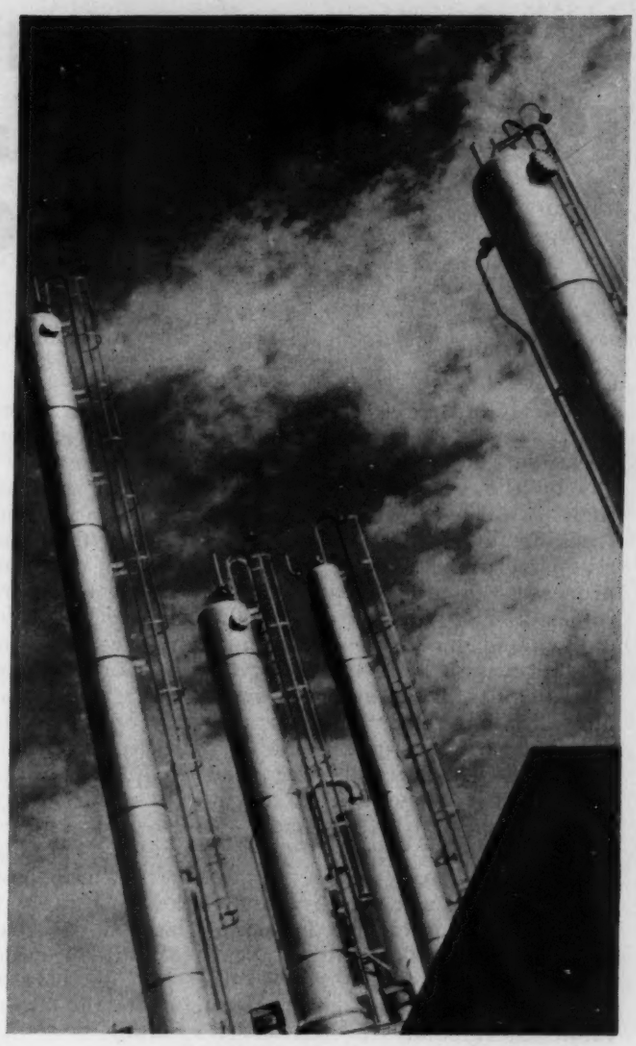
The function of this column is to remove the dissolved ethane from the higher-boiling fractions as well as a part of the hydrogen sulfide. Since the composition of the charge to the column varies, frequent analysis of the material from the base is necessary to maintain the correct ratio of reflux to the feed so that approximately 95 percent of the hydrogen sulfide is removed with a minimum loss of propane. The constants at the column tower pressure and reboiler temperature. The variables are the composition of the feed and the reflux ratio. The amount of feed to the column varies little because the raw gas is gathered under slight vacuum. Formations produce the sour gas under pulsations, which causes the raw charge to contain varying amounts of hydrogen sulfide, which in turn makes frequent adjustments of the sulfur compound.

With the ethane removed and the H_2S reduced by 95 percent, the condensate flows by process pressure to the caustic contractor and into the settling tank. The pressure on the de-ethanizing column is sufficient to move the material through the caustic contactor and settler to the sand filter and then through the cupric chloride treater to the second column of the series. The pressure differential between the de-ethanizing column and the second tower is 125 pounds so pumping in this stage is unnecessary.

The second column is the finished gasoline fractionator which may be operated to produce any grade desired. When the base product from this column is a 14-pound RVP gasoline, the pressure is held at 150 pounds, and the reboiler maintained at 244°F. The feed rate to the column is around 3,700 gallons per hour, and as the overhead is reduced to total condensation, a portion is returned at the rate of about 5400 gallons per hour to maintain the top temperature at 90°F.

The base product from the finished gasoline tower is passed through two coolers in parallel to pressure storage. The overhead product is pumped to the third fractionator to separate the propane from the charge. The column is operated at 260 pounds and the reboiler maintained at 220°F. The overhead product from this column is high percentage propane which is condensed and returned as reflux at a ratio of 2:1 to maintain a top temperature of 96°F. Excess propane is passed at column pressure through an auxiliary column filled with calcium chloride to remove any moisture.

The base product from the propane fractionator flows, at the depropanizing column pressure, to the iso-butane column which is operated at 146 pounds. This column is equipped with 50 bubble plates and is operated with a reboiler temperature of 182°F. Condensed iso-butane is returned to the top of the tower at a reflux-to-feed ratio of 6:1 to maintain the top temperature of 106°F. This column is difficult to operate because of the delicate adjustment required when separating iso- from n-butane. The overhead condensate and the reboiler product of the iso-butane column are run to separate storage under column pressure.



Grouping of Fractionators

Since all of the desired fractions are separated from the raw charge in the various towers and manufactured to specifications in a continuous operation, sweet and non-corrosive without additional treatment, the normal butane and the relatively pure propane are subsequently blended back to produce specification liquified gases either in plant storage, tank cars or transport trucks. Facilities are included in the plant to handle the products as manufactured, and provisions are included in the design and operation to maintain required operating conditions with adequate control apparatus.

The bases of all towers are housed in with reboilers, controls and pumps to protect the equipment from inclement weather and to insure continuous working conditions. Uncondensed vapors from the low-pressure accumulator drums at the distillation equipment are collected, recompressed and cooled to liquid, which is fed into the de-ethanizing column with the gross gasoline from the accumulator tank to insure a minimum loss of lower-boiling fractions.

The Catalytic Hydrogen Peroxide Oxidation of Straight Chain Olefines

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(Translated from Brennstoff Chemie, 20, No. 19; P. 358)

STRAIGHT-CHAIN olefines have assumed recently a wide importance in industrial and scientific research, due to their simple synthesis from water-gas by the Fischer & Tropsch method, as well as their commercial production by thermal catalytic cracking of natural hydrocarbons.[1] Due to their reactivity they are the raw materials for various processes—such as, in production of synthetics, perfumes, and organic syntheses. Their conversion into oxygenated derivatives is accomplished by catalytic oxidation with molecular oxygen. The work, for instance, of H. Hock and co-workers[2] with cyclic and alicyclic definite olefines and also cracked gasolines at low temperatures resulted in hydrocarbon-peroxides, which could be reduced to alpha and beta unsaturated alcohols. The reaction proceeded very slowly—especially with chain olefines—and resulted until recently in very low yields. For instance, only 2 percent peroxides were obtained from n-hexene after 200 hours using both light and chemical catalyst.

Researches on cyclic compounds[3] have shown that hydrogen peroxide in the presence of suitable catalysts gives the same end products as does auto-oxidation, and that, in contradistinction to the latter, labile intermediates do not suffer spontaneous polymerization (resinification), in fact, are completely hindered by a special reaction technique. Employing either alkaline or acidic oxidation-reagents, the reaction proceeds without rearrangements, for instance, due to enolization or ketonizing of the molecule—which ordinarily might influence energy partitioning and the direction of the resulting equilibrium. It is for this reason important to determine the reactive positions in the molecule during the H_2O_2 oxidation in neutral solutions.

Hydrogen peroxide similar to ozone does not give rise to by-products or reduction-products during its reaction, so that it is a simple matter to work up the crude reaction product.

These leads were the reasons that we then sought to expand our work in the field of highly reactive olefines. Such reactions necessitated working in homogeneous phase even though the reaction-mixture was highly diluted both by the water present in 30 percent hydrogen peroxide, and the water formed in the reaction. One had to take care that newly formed, quite volatile soluble oxygenated by-products would be further reacted instead of finding much of the original charge to the process still unconverted. For long-chain higher olefines practically insoluble in aqueous media, we found solvents specially adaptable, namely, acetone and methanol. Both these solvents are somewhat slightly attacked, but are nevertheless much more stable than the olefines. The oxidation reaction without catalysts proceeds very slowly.

As activating catalysts, we tested out the oxides of the heavy metals, which form peracids with H_2O_2 in the oxygen-containing above mentioned solvents. In order to fulfill the requirements for a true catalytic reaction, it is of course one of the main points that these peracids again release the peroxide oxygen. Concerning the selected peracids of vanadium, molybdenum and tungsten,[4] only pervanadic acid, probably $VO_2(OH)_3$ or VO_4H, fulfilled both requirements.[5] The two other acids accepted H_2O_2 but released peroxide oxygen only with great difficulty.

Besides, pervanadic acid possesses another excellent characteristic for controlling the oxidation process—namely, it acts as an indicator going from red to green during the consumption and reaction of the H_2O_2. Furthermore, the various color changes in many cases those from red to reddish yellow and yellow signify the formation of loosely bound intermediates of hydrogen peroxide, which precede the actual reaction.

The catalyst is prepared at the time by introducing Vanadium pentoxide V_2O_5 (0.1 to 1 percent, by weight based on the hydrocarbon) into a 30 percent solution of H_2O_2, during strong cooling. The red solution is added, during stirring, to a mixture of 1 part olefine to 5-10 parts of diluent, previously warmed to 25° C. The temperature is held at 25-35° C., during reaction by an external water-bath, during which time the calculated H_2O_2 is added. At higher temperatures the solvent will be attacked, and at times violently enough to cause rapid and uncontrolled violent boiling. Using the conditions described above it was possible to convert 100 gm. chain olefines to oxygenated derivatives in 30-40 hours. If it is desirable to isolate primary oxygen compounds, it is advantageous to stop the reaction sooner, removing unspent hydrocarbon by adding water, and oxidizing the hydrocarbon further in another test.

It was next desirable to study oxygen derivatives of the paraffins as to their behavior in the presence of hydrogen peroxide attack. For this purpose the reaction mechanism and the formation of the oxygenated products of the olefines had to be determined and simplified as much as possible. Primary alcohols and aldehydes are very stable. In solution in acetone the only visible attack was on the solvent itself. Even in aqueous solution or in dispersion, both groups were only slightly attacked at 60-80° C. by catalyzed H_2O_2. The well known change: Prim. alcohol→aldehyde→mono acid does not take place. Most commonly, a splitting into oxalic and monocarboxyllic acids of shortened chain length will occur after preliminary hydroxylation:

$$R-CH_2-CH_2-CHO \rightarrow R-COOH + COOH-COOH$$

When the catalyst and H_2O_2 in greater concentra-

tion is allowed to react on aldehydes, definite crystalline peroxides can be isolated before being converted to other forms. Pervanadic acid did not in this case act as an oxidation accelerator but it catalyzed as do mineral acids the addition of H_2O_2 on the aldehydic oxygen. The peroxides of high molecular weight aldehydes are inert and non-poisonous compared to those lower in the series. Secondary alcohols are slowly converted by hydrogen peroxide to ketones; unsaturated alcohols add H_2O_2 to the double bond very easily. Paraffinic ketones are quite resistant and more difficult to attack than cyclic ketones and chain olefines. The catalyzed H_2O_2 oxidation initiates here also a hydroxylation—the point of attack being, curiously enough, dependent on the symmetry of the ketone. While methyl-ethyl ketone $CH_3—CO—CH_2—CH_3$ and the symmetrical pentanone-3, $CH_3.CH_2.CO—CH_2.CH_3$ are hydroxylated in the 1,2 position to carbonyl, oxidation takes place in the 1,3 position in the unsymmetrical[6] pentanone-2, $CH_3—CO—CH_2—CH_2—CH_3$.

Increasing the chain length, i.e., undecanone[5] increases the stability. Alpha-keto-alcohols are especially easily and spontaneously split into aldehydes and carbonic acids by H_2O_2. This reaction is similar to Criege's splitting of glycols, and in the case of olefine-oxidation is as follows:

$R—CO—CH(OH) \rightarrow R, \rightarrow R—COOH + R,—CHO$.

The a-glycols with a middle glycol group R—CH(OH)—CH(OH)—R, are quite resistant and do not undergo glycol splitting. Contrary to this, a-glycols with terminal glycol group, are converted by catalyzed H_2O attack at both hydroxyls. (See below.)

All olefine hydrocarbons possess two reactive points that can be attacked:

1. The double bond.
2. The neighboring methyl groups.

Both are usually reactive together indicating that the olefine-molecule exists in various active states, not demonstrable, as the various formulae might indicate—states which are in variable equilibrium with one another, similar to the keto and enol forms in ketone compounds.

a,b, unsaturated alcohols, a-glycols, aldehydes, ozonides and monocarboxyllic acids were proven as reaction products in the pervanadic acid catalyzed H_2O_2 oxidation of chain olefines.

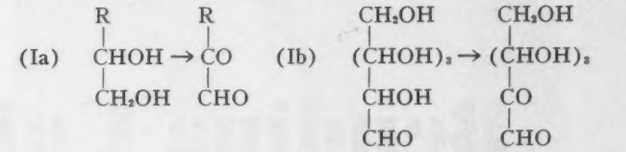
The initial process (primary) is one mainly of hydroxylation. H_2O_2 will either add to the double bond forming a-glycols, or it will attack the neighboring methyl group giving rise to a, b, unsaturated alcohols. In a series of cyclo-olefines it was long known that the double bonds actually activated the methyl groups. W. Triebs and H. Schmid[7] had shown that, by chromic acid oxidation of a-octylene the same was true for chain olefines. In the case of the a, b unsaturated alcohols the open bond must be partly saturated by the adjacent hydroxyl group, since this alone can explain their low reactivity.

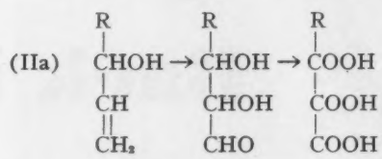
The above mentioned primary products so formed are partially susceptible to further oxidation. Further conversion is very dependent on the position of the double bond in the original olefine, wherein two cases arise:

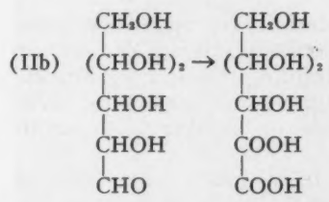
1. Olefines with terminal double bonds yield unstable a-glycols which by H_2O_2 are further oxidized at both hydroxyl groups, finally yielding crystalline ozonides (Ia). Their a, b unsaturated alcohols of strong persistent odor and sweet taste are slowly split into oxalic and into monocarboxylic acids containing two less carbon atoms by the action of hydrogen peroxide. (IIa)

The tests comprised using a-octylene, C_8H_{16}, a decylene, $C_{10}H_{20}$, and a-dodecylene, $C_{12}H_{24}$; these hydrocarbons were prepared from their primary alcohols by thermally splitting off water passing the original alcohol over unglazed porcelain tile.[8]

These transformations of a-glycols and a, b unsaturated alcohols are similar to reactions well known in the chemistry of sugar; sugar, the aldoses and ketoses are converted into ozonides[9] by H_2O_2 (Ib). Strong and energetic reaction of the oxidizing agent will split glucose into oxalic acid and trioxy succinic acid (IIb)[10]:







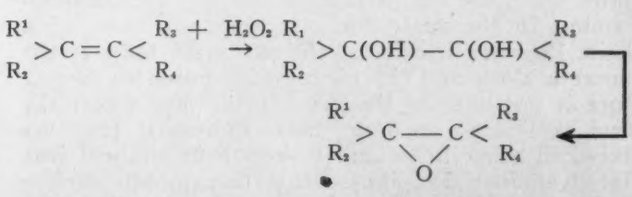
2. In contrast to the above olefines with a central double bond yield definite crystalline glycols. Small amounts of a, b unsaturated alcohols which form are partially further oxidized to the corresponding ketones; then add further hydrogen peroxide at their double bonds and degrade to aldehydes and acids.

Tests were made with n-undecene[5] $C_{11}H_{22}$ and with n-tetradecene, $C_{14}H_{28}$. Both alcohols were first prepared by Grignard reaction from heptylaldehyde in the one case and butyl (by heptyl bromide) in the second case, $—C_{11}H_{24}O$ and $C_{14}H_{30}O$ alcohols. The latter were then converted into the respective olefines by means of anhydrous zinc chloride.

Side chains, derived from ethylene structures, accelerate the formation of isomeric oxidation products and a splitting of the molecule at the double bond.

These olefines were prepared from the alcohols by reaction of butyric acid ester and 2 mols. ethyl or propyl magnesium bromide, and from acetic ester and 2 mols of isoamyl-magnesium bromide.

When two side chains branch off from both carbons in the ethylene bridge, and if these carbons are free of hydrogen linkages, then the a-glycols, at point of formation, will split off water and convert to a-oxides;



Such hydrocarbons were also made from butyric

acid ester and 2 mols of alkyl bromide by Grignard reaction.

The proof of the formation of these oxides lead at the beginning to the erroneous view that pervanadic acid will convert olefines directly into a-oxides, as does benzoic peracid. In the case of the hydrogen-free semi-cyclic ethylene derivatives, there occurred a similar spontaneous conversion of the a-glycols so formed into a-oxides-pointing to the presence of an underlying general rule in these reactions.

Chain and cyclo-olefines behave similarly, in qualitative formation of products, in the pervanadic acid catalyzed hydrogen peroxide oxidation. Both add on H_2O_2 at the double bond and there is the hydroxylation of adjacent reactive methylene groups. Usually in most cases the first reaction occurs with the chain olefines and the second in the case of the simple cyclo-olefines.

Whether these results also apply to auto-oxidations would require the accumulation and study of further laboratory studies.

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Bending Units Puts Pipe Back in Use

SINCE replacement materials are becoming more difficult to obtain, particularly those of certain shapes, the Old Dutch Refining Company, Muskegon, Michigan, has designed an apparatus with which pipe bends are made for hooking up pumps and vessels.

A concrete block near the welder's shed, has the following dimensions: overall length, 12 feet; width, 6 feet; depth, 5 feet, forming a mass containing 360 cubic feet. The block rises only a foot above the ground level to make pipe handling easier. Extra heavy pipe nipples, 2 inches in diameter, extend from flush with the surface through the block, spaced on 12 inch centers in which steel pins are driven with a push fit, to allow forming any combination of bends. In one corner of the block is a structural steel loop imbedded as an anchor for a large capacity chain hoist.

A heating furnace is located at one end of the concrete block, made of fire brick, and covered with a sheet of tank steel. Two ends are open in the furnace so that pipe of any size may be worked and moved while being heated by a large capacity gas burner set in one side of the heating furnace. The burner assembly is set loosely in the walls of the furnace to allow some latitude while heating by directing the flame back and forth along the pipe.

When bending pipe, the nipple is cut to the required length for connecting the units desired and is then placed in the furnace with the burner adjusted to produce the necessary heat for softening the metal. Both ends of the nipple of pipe are closed with a plate welded in, allowance is made for removing these plates when the nipple is measured up, with a small opening in the plate for attaching the hook of a chain. Pins are inserted in the necessary holes in the concrete block and the hot pipe anchored to two or more at one end. At the point in the pipe where the bend is started, two or more additional pins are placed in other holes and a section of channel iron placed against the pins so that the smooth surface of the channel iron is against the pipe on the inside

of the bend. A second chain is attached to the opposite end of the pipe to which the hook of the lower falls of the chain hoist are attached for bending.

On ordinary bends, two men operate the apparatus to furnish sufficient power that the bend is made easily and without undue exertion on the part of the operators. As the point in the pipe where the bend first begins is at the section of channel iron nearest the anchored end of the pipe nipple, water is poured on the hot pipe after the proper shape has been started, so that a uniform arc will be obtained. Should the pipe become too cold for proper shaping, a small gas burner attached to a pipe nipple and fuel hose is used to play the flame along the metal at the required sections for maintaining the necessary temperature for working the steel.

As the arc is being formed, the anchor posts are changed to adapt to changed position and direction of the pull, so that the power attached to the opposite end of the pipe is always applied in the same direction. Any size pipe within the limits of the bending equipment is handled. In some cases the pipe is filled with packed sand to prevent deformations resembling wrinkle bellies from appearing on the inside of the arc.

Water and Chemicals Accomplish Salt Removal

WHEN a topping unit was added to the plant of Rothchild Oil Company, Santa Fe Springs, California, provision was made for removing the major part of the salt content, 70 pounds per 1000 barrels. The first step is the introduction of 6 percent by volume of fresh cold water through a mixing nozzle so as to form an emulsion. Then a treating chemical is introduced after the charge takes its first preheat by exchange. After a second preheat by exchange the raw charge passes to a desalting drum.

The combination reduces salt content to around 7 pounds per 1000 barrels.

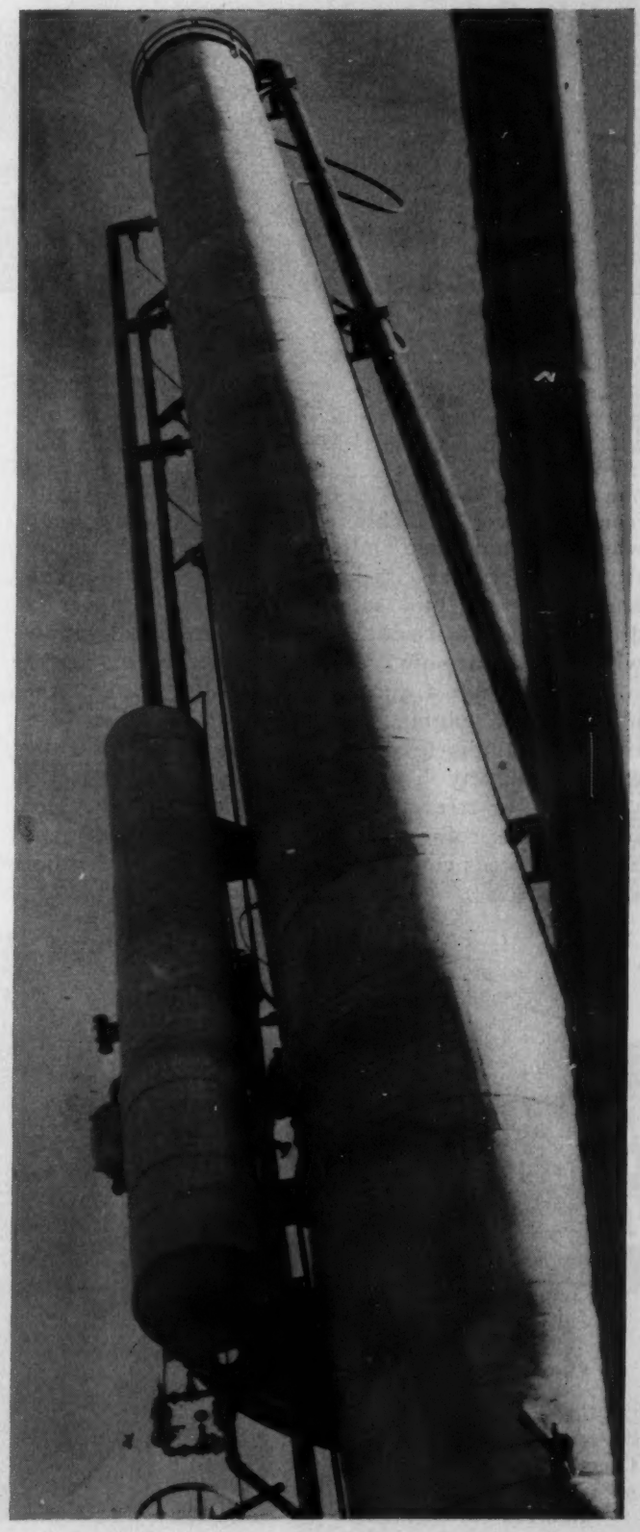
Fresh water is introduced at the suction of the reciprocating charge pump and is metered for accuracy. After gaining the contact provided by a special mixing nozzle, the charge goes to the first of three heat-exchanger units, where sufficient heat is provided to permit chemical action and the emulsion-breaking agent is introduced at this point.

In the second topped-crude-to-charge-stock heat exchanger temperature is raised to around 300 degrees after which the oil, water and chemical enter the horizontal desalting drum, 6 feet in diameter and 43 feet long, where the water is drawn off and the oil continues through the topping plant.

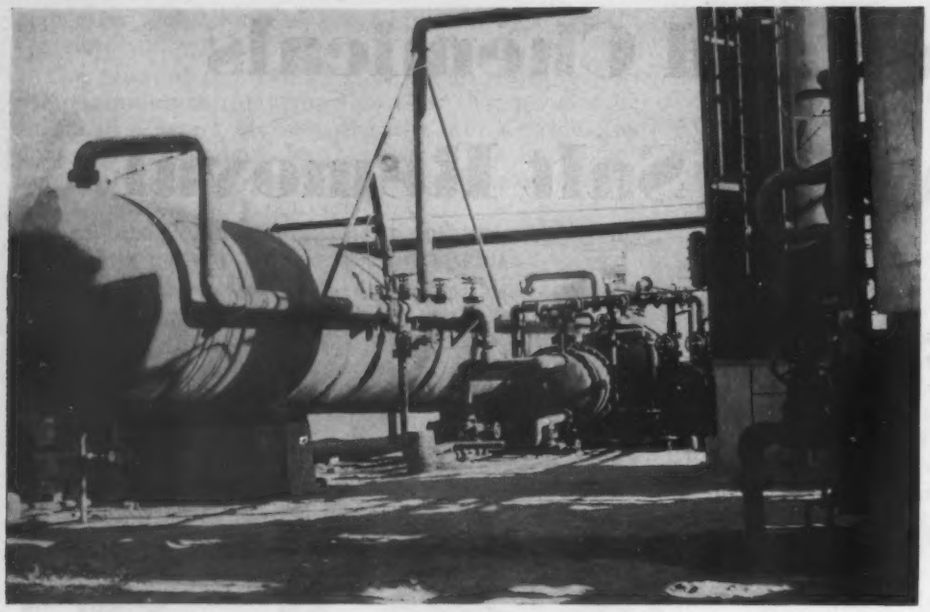
This vessel is mounted on concrete piers with one end 30 inches higher than the other. The charge enters the drum at the top of the shell at the low end, passing to the interior through a perforated line extended along the bottom for 16 feet. Baffles are used inside the drum to bring about complete separation of the aqueous solution from the oil. Tell-tale cocks at the lower end of the drum are used to determine the water level, which is controlled by bleeding to disposal lines continuously.

Although the vessel has adequate insulation, the temperature of the oil is lowered at the drum outlet to 280°F. This is raised to 300°F. in the last of the three exchangers between the drum outlet and the flash column. A pressure controlling valve in the commodity line reduces the pressure from 140 pounds to 15 pounds for flashing the first cut of gasoline from the crude in the small column. The gasoline produced in this tower is controlled with reflux to 350°F. end point, while the bottoms flow to the tube still.

The still has both radiant and convection sections, with 600 lineal feet of 3-inch tubes in the convection and 1900 lineal feet of 4-inch tubes in the radiant side. Fired with gas, this heater raises the temperature of the crude to 675°F. on the transfer line to the main column of the plant. This tower, 5 feet inside diameter and 100 feet 6 inches tall, has 45



Reboiler on side of column which vaporizes light ends from top side cut of naphtha.



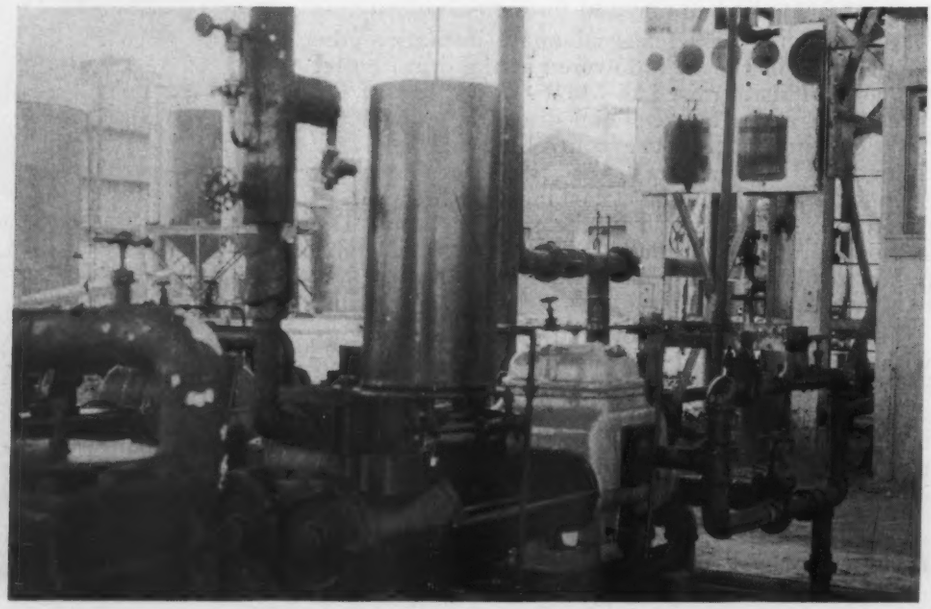
Desalting drum and residuum exchangers used to remove salt from charging stock.

bubble trays, 39 of which are fractionating and 6 stripping.

Three side cuts are made from this tower. The top cut is controlled to 350°F.-end-point gasoline by column reflux. The next cut is a naphtha taken from one of three draw-off points near the top, usually from the lower one. This is diverted to a side column where a liquid-level controller determines the quantity of material received from the fractionating column. Near the mid section of the main tower, a draw-off pan is used to remove kerosene distillate which flows through a liquid-level controller on the column through a pancake coil in the base of the naphtha side column. The heat of the kerosene distillate stream is used in this manner as a reboiler to vaporize any lighter cuts withdrawn from the tower by the stream of naphtha, vapors from which re-enter the column above the top draw-off pan. This product is controlled to 437°F. end point, which is adaptable for blending with other products for gasoline.

The kerosene distillate has a boiling range from 445° to 525°F. as it is produced from the draw-off pan. The bottoms, being topped crude, are charged from the receiver, after passing through the charge to bottoms exchanger, directly to the cracking plant.

When the plant first started operating, the present mode of running was placed in effect, except that the chemical was introduced into the wet crude at the pump discharge. This method of introducing the emulsion-breaking chemical was not efficient, as the reaction was in reverse; no emulsion being formed to dissolve and remove the NaCl. Upon investigating, it was decided that the proportioning pump discharge line should be connected down stream from the first bottoms-to-charge exchanger so that sufficient time could be provided to form the effective mixing, and temperature would be available for rapid breaking out of the emulsion.



Chemical supply tank mounted on steam end of charge pump to break out emulsion.

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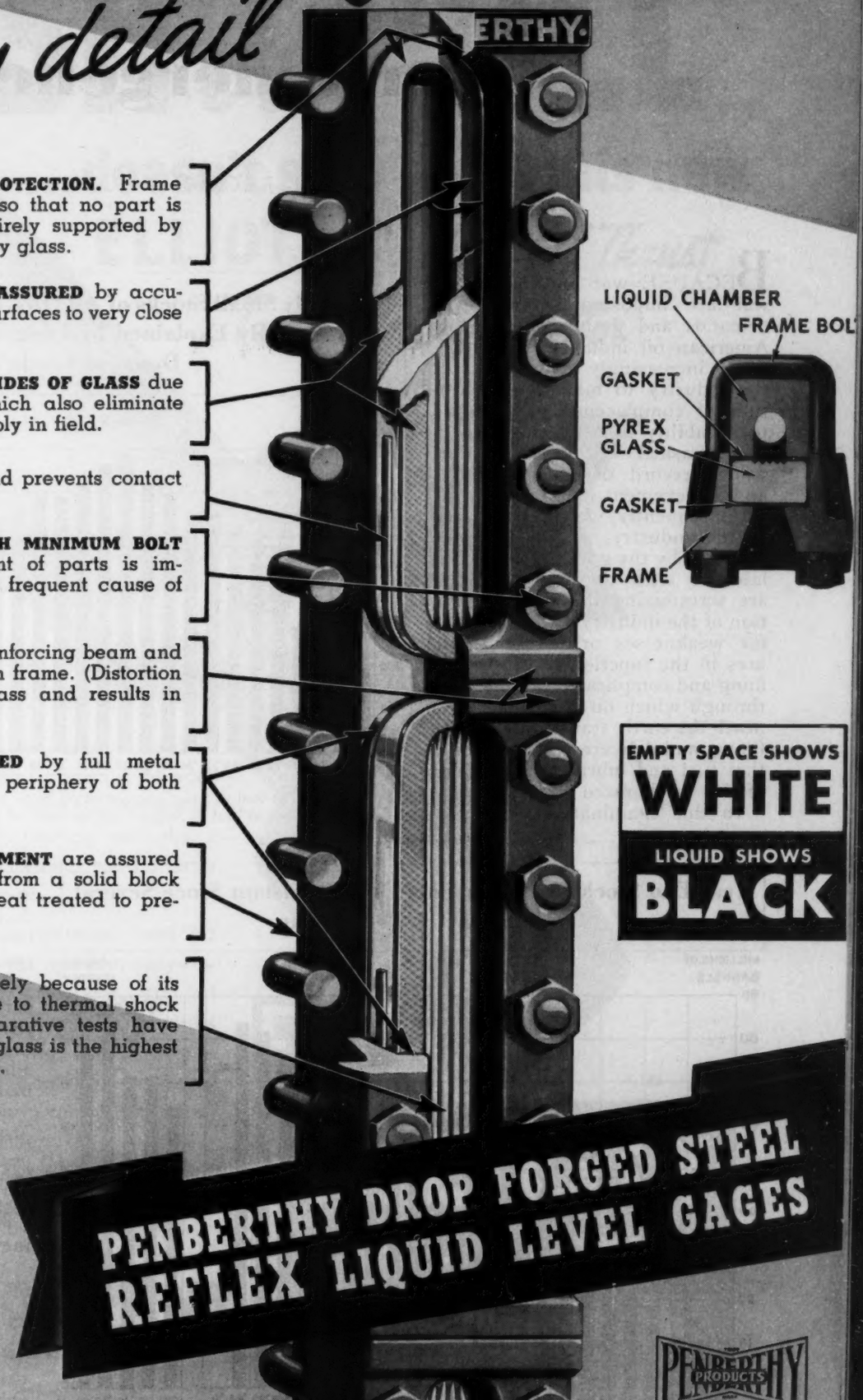

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Stock Situation in Light of War Emergency

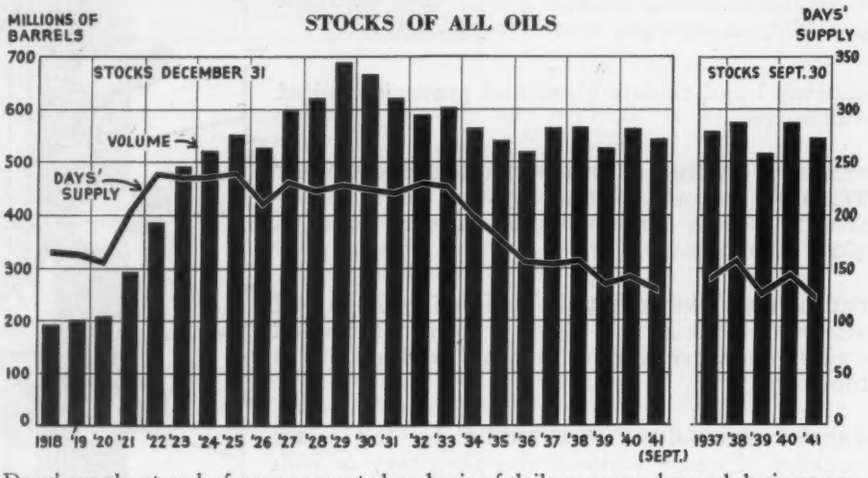
L. J. LOGAN

BECAUSE war and threats of war are imposing extraordinary demands and problems upon the American oil industry, it has become increasingly dangerous for the industry to maintain an attitude of complacency with regard to its ability to perform whatever may be asked of it, despite its marvelous record of resourcefulness and achievement in the past.

Consequently, far-sighted men of the industry, as well as men assigned by the government to collaborate with the industry, now are scrutinizing the whole operation of the industry with eyes open for weaknesses or potential failures in the functioning of the far-flung and complicated organization through which oil is found far beneath the earth, transformed by refining, and delivered into the tanks that fuel and lubricate the wheels of this mechanized nation.

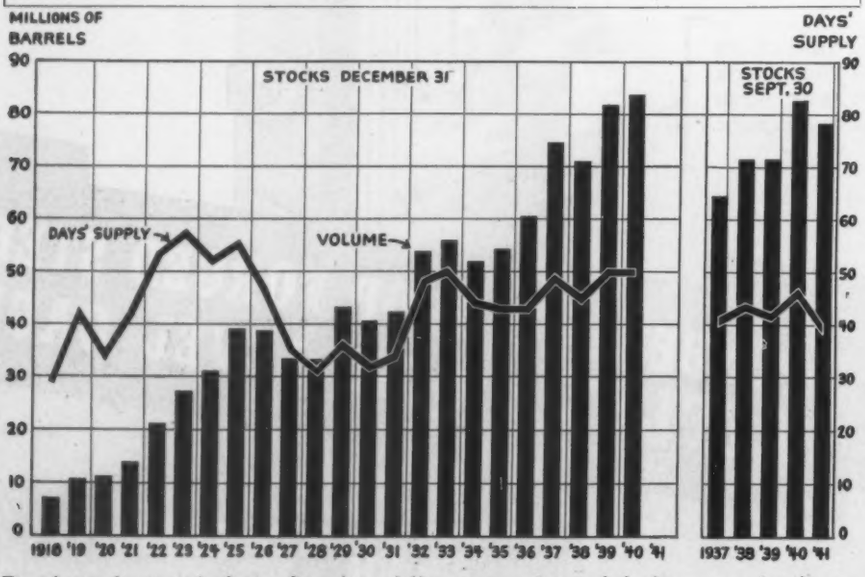
In this examination of the industry, the inspectors have come upon and are carefully studying that part of the industrial operation represented by above-ground stocks of crude and refined oils.

Relatively Small Stocks of All Oils, in Terms of Days' Supply, Largely Explained by Long and Steady Cutting Down of Crude Storage



Days' supply at end of year computed on basis of daily average demand during year and days' supply at end of September on basis of daily average demand during month.

Year-End Stocks of Motor Fuel Fairly Constant Since Several Years After World War



Days' supply at end of year based on daily average demand during year; days' supply at end of September based on daily average demand during succeeding month.

In the light of all which is occurring and which may occur, they ponder, is there any danger that the existing stocks may prove inadequate; would it be advisable to increase them while we may?

This question has been raised rather quietly, but it has been repeated on all sides until it is asked in a voluminous chorus, which magnifies the question mark into one of the largest now confronting the industry.

With the purpose of showing clearly where the industry now stands, as compared with positions in earlier years, in regard to stocks of crude and of the various products, there are presented several charts, which measure stocks in terms of days' supply at prevailing rates of consumption; and along

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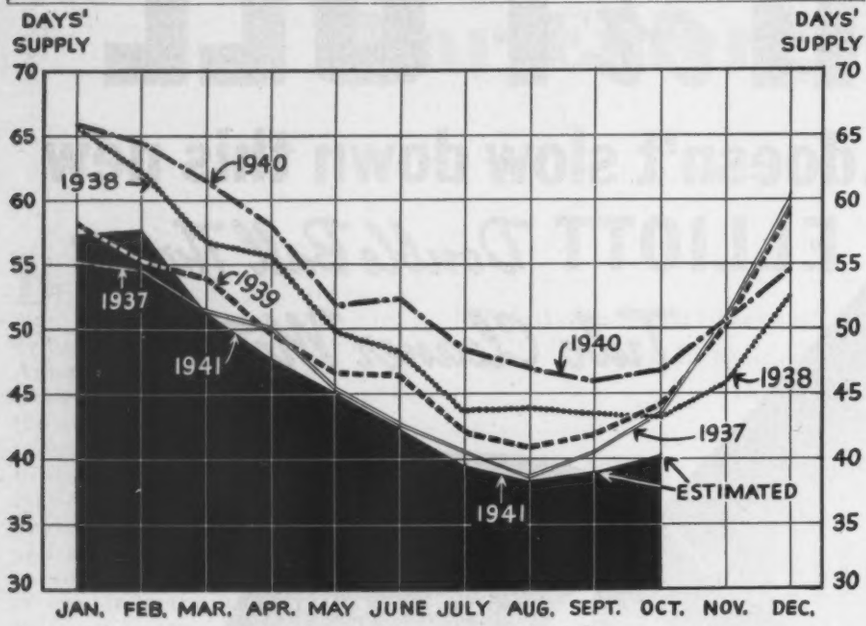


Days' supply of motor fuel on hand in United States at end of month computed on basis of demand, domestic and export, in succeeding month.

with the charts is offered factual discussion of several of the important phases of the problem.

(1) **All Oils.** Stocks of all oils, crude and refined, measured in terms of days' supply at current rates of consumption, are today at the lowest level ever reached in modern times, being smaller than after the August, 1939, shutdowns of Mid-Continent oil fields for half a month, substantially smaller than during the World War, and only half as large as during the 1920's and early 1930's. The stocks of 544,216,000 barrels on hand September 30, 1941, represented only 121 days' supply on the basis of demand during September and 28 days' supply on the basis of demand in the first 9 months of 1941. In contrast, stocks at the end of 1918 represented 165, days' supply, and from 1922 through 1933, stocks represented 220 to 240 days' supply.

Changes in stocks of all oils are of limited significance, however, as they have been determined largely by changes in crude stocks, with the inventories of refined products in the aggregate relatively constant. The chart for stocks of all oils is closely similar, therefore, to that for stocks of crude oil.

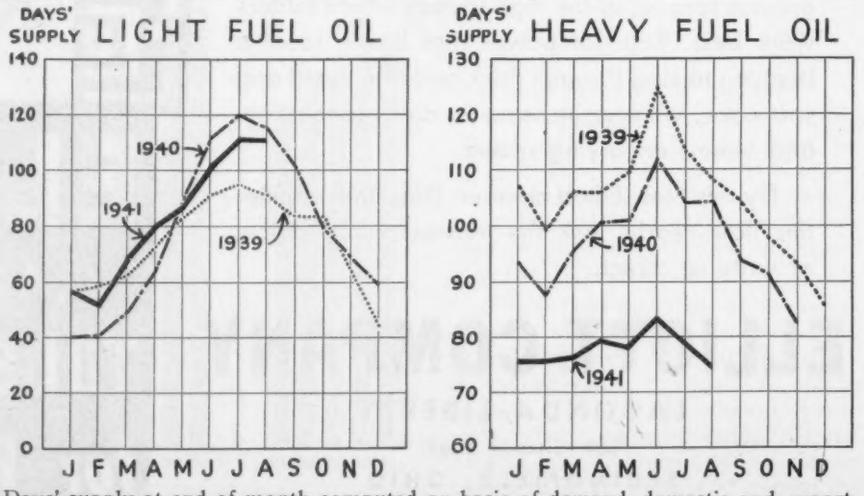
(2) **Refined Products.** The fact that stocks of all oils have varied with those of crude has reflected the relatively small changes through the years in days' supply of refined products. Even within any year, changes in aggregate product stocks are narrow, as the only important products showing distinct seasonal changes in stocks are gasoline and fuel oil, while changes for those two products are almost diametrically opposed, the total stocks of the two, in actual volume, being virtually a straight line that trends upward because of the steady over-all increase in gasoline stocks.

Total stocks of refined products on September 30, 1941, amounted to 282,411,000 barrels, and were not far from the all-time high, having been gradually increased in line with the steady growth in demand. Although the total was 12,000,000 barrels under a year previously, the reduction was almost wholly in stocks of heavy fuel oil in California.

On the basis of total demand for petroleum products during September, the September 30, 1941, stocks of refined products represented 63 days' supply, and on the basis of demand in the first 9 months of 1941, they represented 66 days' supply. Those figures were close to the average for the past 7 years, as end-of-year stocks from 1934 through 1940 ranged between 65 to 75 days' supply although higher figures were indicated during the depression years, because of abnormally low demand.

(3) **Motor Fuel.** Although stocks of motor fuel have been steadily expanded through the years, the increase has been in line with growth of consumption; and in terms of days' supply, present stocks are not far from the average maintained since the World War. End-of-year stocks of motor fuel, expressed in days' supply on the basis of daily average demand during the year, nearly always have fallen within a range of 40 to 50 days' requirements, or on the basis of demand in the succeeding Janu-

Stocks of Light Fuel Oil Normal This Year; Those of Heavy Fuel Oil Lower in Reflection of Reductions in California



Days' supply at end of month computed on basis of demand, domestic and export, in succeeding month.

Strain and speed are hardest to handle *at the turns* in PIPING, too!

On a bobsled run, constant danger lies at the banked turns. Here the utmost skill of the driver and braker are required to avert an accident. (*I.N.S. photo*).

Insure safer, stronger, trouble-free piping systems with TUBE-TURN welding fittings

When the fluids or gases in your piping systems zoom through the lines and swerve into the turns—*added* strain and friction strike the fittings and joints. Trouble usually develops here *first* in any piping system *because the most danger lies at the turns!*

Weld with TUBE-TURN fittings and *your* plant piping systems will last far longer, function more efficiently and safely, save valuable space, and cut upkeep costs.

There is a TUBE-TURN for *every change in flow direction*—elbows, returns, tees, reducers, laterals, nipples and flanges—made with Tube-Turns' exclusive forging process to give unequalled reinforcement at these danger spots.

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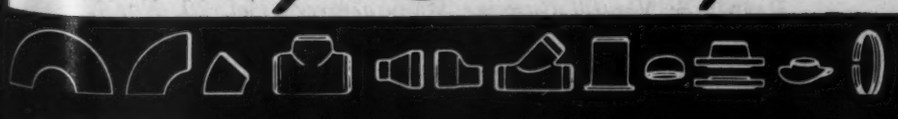
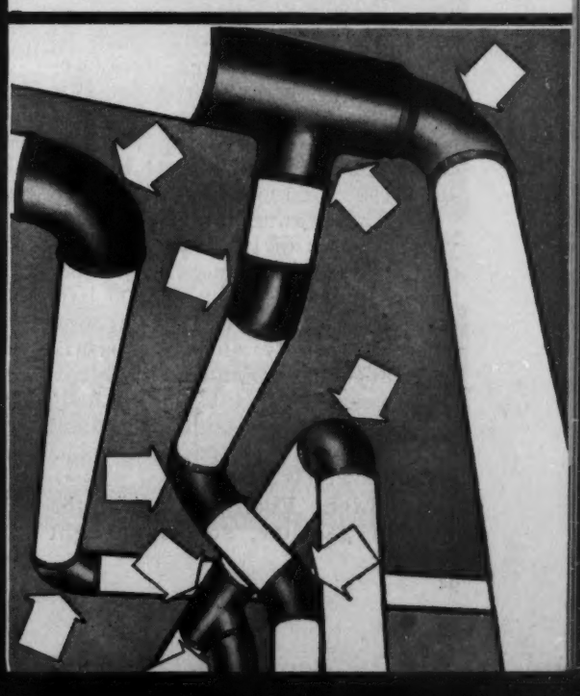
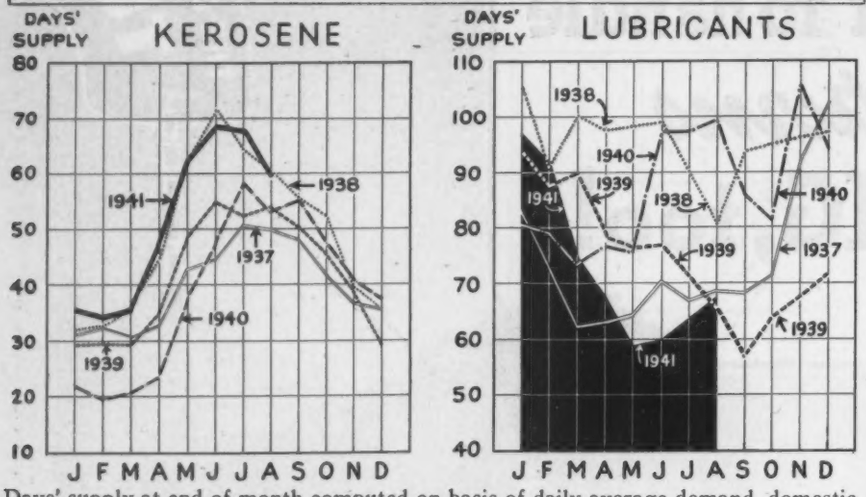


WELDING WITH TUBE-TURNS REMOVES "DANGER AT THE TURNS" IN PIPING

When you think of "turns" in piping systems, remember they occur within tees, reducers, laterals, nipples, heads, etc., as well as within elbows and returns. Wherever there are abrupt *changes in flow direction* you'll find *extra* wear and tear. TUBE-TURN welding fittings provide maximum *extra* strength and safety, and practically eliminate maintenance troubles, at these *danger spots.*



Kerosene Stocks Relatively Large in 1941; Lubricant Stocks Low in Relation to Use



Days' supply at end of month computed on basis of daily average demand, domestic and export, during succeeding month.

ary within a range of 50 to 60 days' supply; and this year will not bring a great variation from the normal trend. However, as shown on the chart giving monthly changes, the curve showing days' supply at end of the month in 1941 has run consistently under similar curves for all years back through 1937, attesting the fact that the industry has been operating this year with somewhat smaller than normal days' supply of motor fuel in storage.

(4) **Kerosene.** Stocks of kerosene have shown relatively little change since the World War, as regards both volume and days' supply with December 31 stocks commonly representing around 50 days' requirements on the basis of daily average demand during the year. The curve of days' supply varies widely within a year, however, when stocks are measured on the basis of changes from month to month in daily average consumption. The monthly curve for this year practically coincides with that for 1938, and days' supply has been consistently higher in 1941 than in 1937, 1939, or 1940.

(5) **Lubricants.** For the past 15 years, stocks of lubricants on December 31 have been generally between 7,000,000 and 9,000,000 barrels representing usually around 90 days' supply on the basis of daily average demand for the year. This year, lubricant stocks have been, however, exceptionally small in relation to demand, which has been extremely heavy.

(6) **Light Fuel Oil.** As in the case of gasoline, stocks of light fuel oil are being increased steadily in volume, because of growing demand; and moreover, there has been some build-up representing a larger margin of safety in supplying demand. The curve of days' supply for 1941, by months, has been close to the trends of 1939 and 1940.

(7) **Heavy Fuel Oil.** Stocks of heavy fuel oil have been substantially reduced in recent years but largely in reflection of withdrawals in California. Heavy drafts in that state as well as relatively large current consumption account for the fact that stocks so far in 1941 have represented only around 80 days' supply, against about 100 days' supply in corresponding months of 1939 and 1940.

(8) **Crude Oil.** As indicated previously, the most significant changes in stocks in recent years have been those involving crude oil. At the end of 1921 crude stocks in the United States totaled 217,324,000 barrels, but by the close of 1922 they stood at 295,708,000 barrels, representing over 150 days' supply, on the basis of demand for crude in the succeeding January. Thereafter, the crude stocks were built up to a peak of 428,445,000 barrels at the end of 1929, although days' supply continued around 150, with demand increasing. After 1929 the industry entered upon a long period of withdrawals from crude storage, and at the end of 1939 it had on hand only 238,910,000 barrels, representing 65 days' supply. Currently it is in nearly the same position as at the end of 1939, having had on hand 246,111,000 barrels of refinable crude on September 30, equivalent to 58 days' requirements at the September rate of demand for crude.

All signs indicate that crude inventories are very close to the levels representing minimum working stocks. They are only a few millions of barrels in excess of the total on hand in late 1939 after the Mid-Continent oil field shutdowns, and those shutdowns forced some refineries to curtail runs sharply because of inadequacy of crude and made it apparent that the industry would have difficulty in maintaining normal operations if much more crude came out of storage. The experience at that time con-

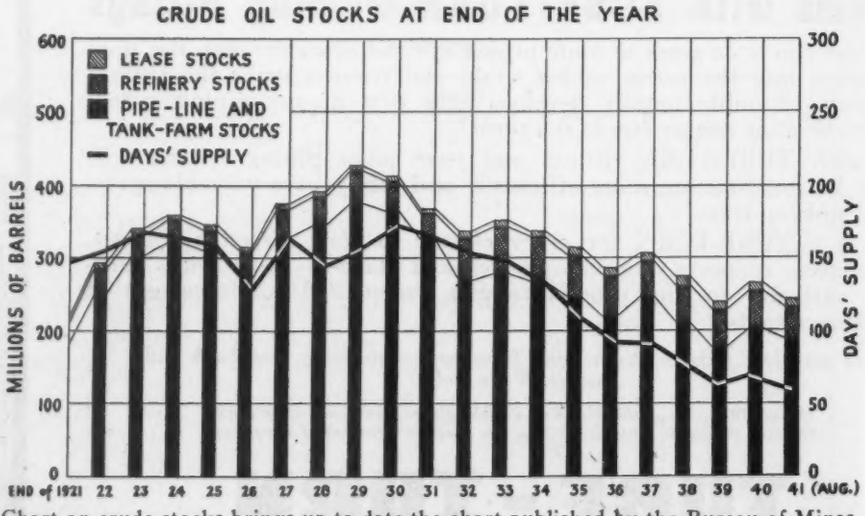
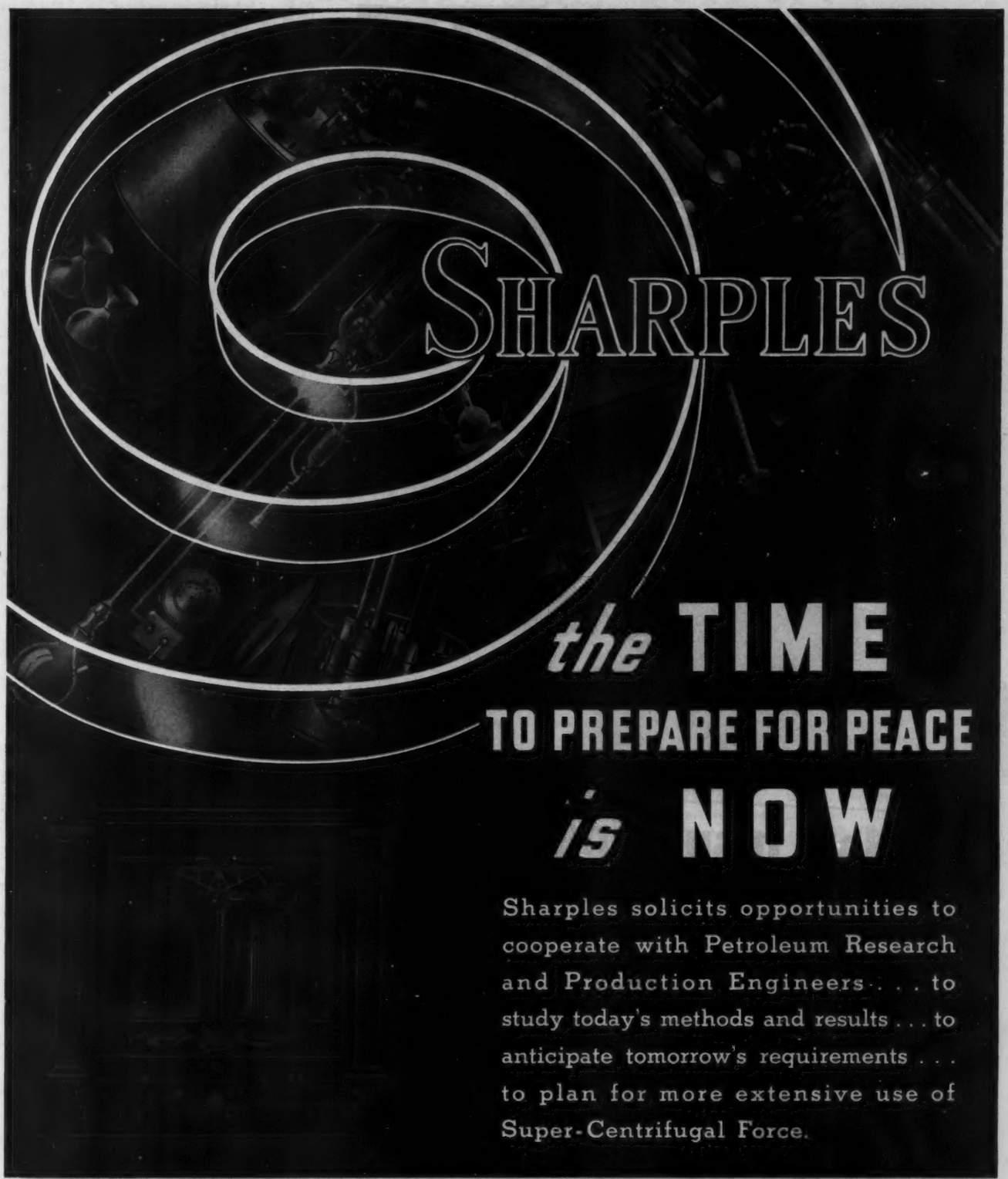


Chart on crude stocks brings up to date the chart published by the Bureau of Mines in its Report of Investigations 3417, September, 1938, on a survey of crude oil in storage. Days' supply curve measures nation's refinable crude on December 31 in terms of daily average demand in succeeding month, January, the demand for crude being found by adding domestic production and imports and by taking into consideration changes in stocks.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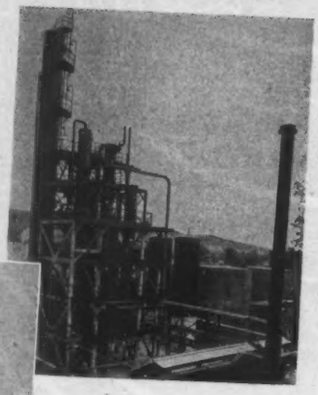

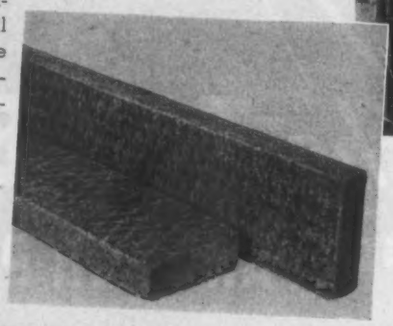

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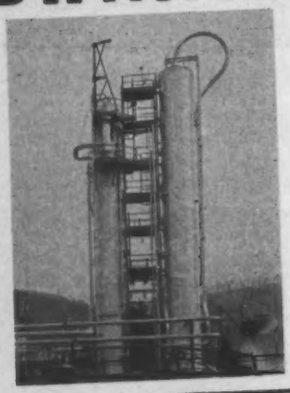

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firmed the findings of the Bureau of Mines in its Report of Investigations 3417, dated September, 1938, and summarized in this publication October 10, 1938, pages 23 to 25. In that report, made following a special, comprehensive survey of crude oil in storage, the bureau found that the industry apparently needed in storage between 200,000,000 and 250,000,000 barrels of crude.

At the time of the survey, it was found, the minimum working stocks of crude oil required for operation of the industry were approximately 105,000,000 barrels, which represented oil that did not remain in one place for more than a few days. That amount included about 11,000,000 barrels on leases for maintaining adequate deliveries to pipe lines, 21,000,000 barrels actually contained in gathering and trunk pipe lines, 12,000,000 barrels contained in minimum working tanks for main trunk line operations, 10,000,000 barrels of essential terminal storage, at gathering line terminals, main line transhipment points, and main line terminals, 4,000,000 barrels in transit to domestic refineries by barge or tank ship, and 47,000,000 barrels at refineries, representing a minimum safety factor of about two weeks' supply. In view of the characteristics of petroleum operations and the organization of the industry, however, the bureau stated, it probably was necessary to have at least 100,000,000 barrels of contingent reserves above ground, in addition to the 105,000,000 barrels of true working stocks, to meet all of the industry's varied needs. The figures indicated, therefore, that the industry needed stocks of at least 200,000,000 barrels.

The report pointed out in conclusion that although the survey indicated a minimum of crude stocks ranging from 200,000,000 to 250,000,000 barrels as necessary, no exact level of desirable crude stocks could be fixed without a detailed analysis of individual company positions and policy and without more accurate information than that available concerning potential reserves and the extent to which a program of underground storage had replaced above ground storage. Without such information, it was stated, a considerable factor of safety in stocks undoubtedly is necessary in an industry in which production and demand are subject to such rapid change.

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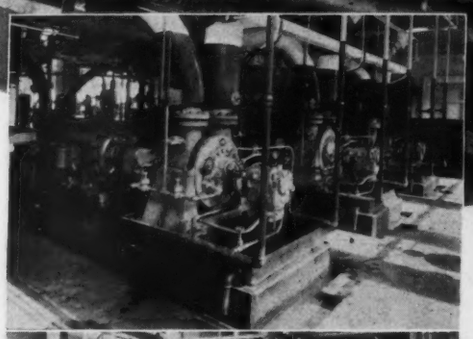

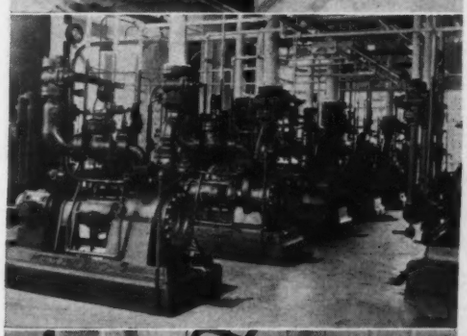

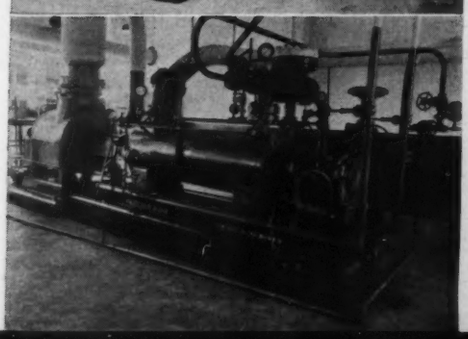

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High Demand Makes Desirable Large Product-Crude Output

ALTHOUGH refinery runs and crude-oil production have been running in recent weeks at all-time record levels, in response to unprecedented demand for petroleum products, continuation of operations approximately at present levels will be necessary throughout the first half of 1942 in order to satisfy the still-greater requirements ahead.

The largest runs to stills heretofore were those averaging 4,120,000 barrels daily in the week ended October 18, but the Bureau of Mines in its forecast for December has pointed out the desirability of maintaining approximately that high rate of refinery operations throughout the winter.

Continuation of runs to stills at an approximate level of 4,100,000 barrels daily during the first half of 1942, including 3,500,000 east of California and 600,000 in California, would represent an increase of about 400,000 barrels daily over the relatively low operations in the first half of 1941, according to the bureau; and such runs would take care of a considerable part of the expected increase in demand for 1942.

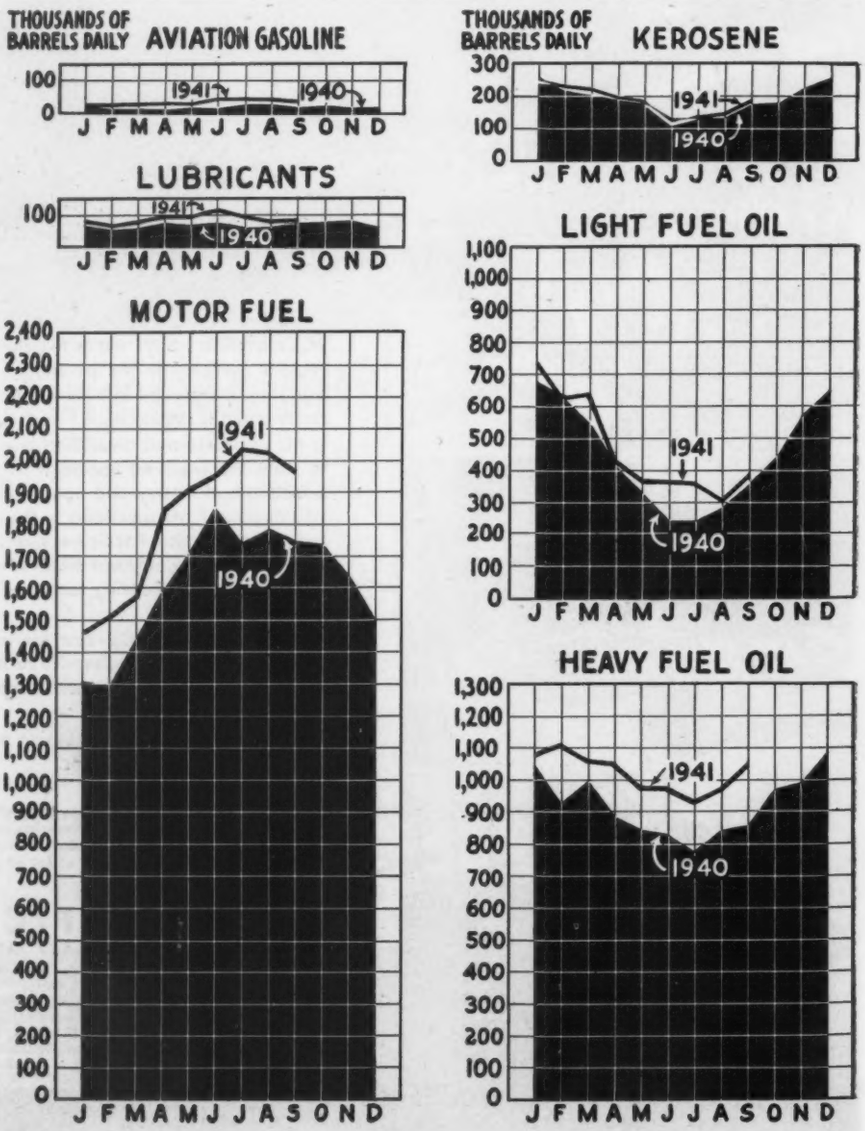
Continued large runs are needed particularly east of California, the agency advised, for in the districts east of that state, runs to stills may be already close to refinery capacity, and the maintenance of stocks of refined products at higher-than-normal seasonal levels seems essential in anticipation of the further increases in demand during the coming year. Much of the present national surplus in refinery capacity is located in California, the report stated, where its use will be limited by the availability of tankers for foreign or intercoastal shipments.

Weather conditions so far have been advantageous in their immediate effect on the industry's inventory situation, as the unusually mild fall has minimized the danger of any scarcity of heating oil. Demand for gasoline has been running at a high level, but heating-oil consumption at the same time has been below normal expectations, with the result that distillate-fuel-oil stocks are relatively large. Consequently, it is indicated that gasoline yields above normal may be permitted during the winter, and thereby it may be easier to provide ample supplies of that product for meeting next summer's heavy requirements.

Nevertheless, the supply of residual fuel oil for industry and the navy may become a serious problem, the Bureau of Mines pointed

This Year Brings Record Domestic Use of Oil Products

Based on Bureau of Mines data, charts show daily average domestic demand for principal petroleum products, by months, in 1940 and 1941.



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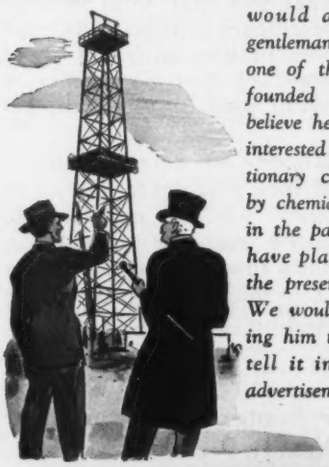
Suppose someone who lived forty or fifty years ago —say one of the founders of Mathieson— could pay us a visit today. And suppose we could have the pleasure of showing him the sights of 1940, of explaining the vast changes that have taken place since the turn of the century. What do you think would amaze the old gentleman most? If he were one of the pioneers who founded Mathieson, we believe he would be most interested in the revolutionary changes wrought by chemical progress and in the part his successors have played in building the present-day America. We would go about telling him the story as we tell it in this series of advertisements.



● **You look astonished, Mr. M., as well you may. Petroleum's importance was only beginning to be appreciated in your day. You could not foresee the time when it would be one of the prime essentials of industrial civilization, and nations would put a far higher value on the possession of oil fields than on deposits of gold or diamonds.**

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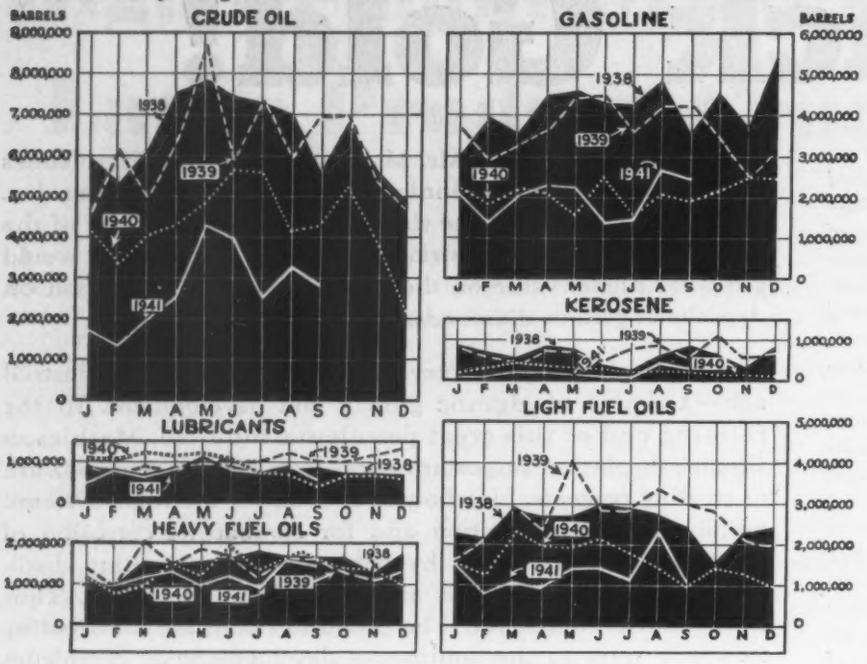
Monthly Exports of Most Products Above 1940 Curve



sion to the end of 1941 of trends traced throughout the year by domestic use and in recent months by exports, which finally have turned back upward after a protracted decline. In September, latest month for which official figures on demand are available, total demand for motor fuel was 13.4 percent above a year before, and for the first 9 months of 1941, the gain was 11.1 percent.

As usual, this year, total demand for all petroleum products has been fairly well in line with the trend for motor fuel. For September, a 13.1 percent year-to-year gain occurred.

Breakdowns of demand for all the principal petroleum products, by domestic use and exports, appear in the accompanying table, giving data for September and for the first 9 months and including corresponding figures for a year previous.

out; and an adequate supply may be dependent upon: (1) the extent to which a profitable market will stimulate refinery yields and production, (2) direct use of crude for fuel, or (3) ability to increase imports from Caribbean sources.

While the bureau recognized the desirability of large refinery runs and maintenance of above-normal stocks of refined products, and pointed out that the relation between refinery capacity and refined-oil stocks to increased demand east of California was the principal problem confronting the industry, it also took a similar view toward crude stocks. "No further heavy liquidation of crude stocks seems desirable," the agency stated, "and a substantial increase would be a wise precaution."

At least through December, exceptionally large year-to-year increases in demand for petroleum products have been indicated. In its December forecast, the Bureau of Mines estimated that domestic demand for motor fuel would be 12.5 percent greater than the actual demand in December last year; and that exports would total 2,800,000 barrels, against actual shipments of 1,983,000 barrels a year earlier. The indicated total demand for motor fuel in December is, therefore, 13.6 percent above the actual last year.

This forecast is closely in line with gains foreseen for November and October, and indicates exten-

Total Oil Demand Up 13 Percent for September Over Year Ago; Gain for First 9 Months Nearly 9 Percent

(Figures indicate barrels, and are from the Bureau of Mines)

	SEPTEMBER			FIRST 9 MONTHS		
	1940	1941	Percent Change	1940	1941	Percent Change
SUMMARY—						
Total Demand	119,639,000	135,285,000	+ 13.1	1,071,329,000	1,160,590,000	+ 8.3
Daily Average	3,988,000	4,510,000	+ 13.1	3,910,000	4,251,000	+ 8.7
Exports:						
Crude Petroleum	4,260,000	2,900,000	— 31.9	40,452,000	25,619,000	— 36.7
Refined Products	5,288,000	[1]6,248,000	+ 18.2	61,983,000	49,618,000	— 19.9
Total Exports	9,548,000	9,148,000	— 4.2	102,435,000	75,237,000	— 26.5
Domestic Demand:						
Total Domestic Demand	110,091,000	126,137,000	+ 14.6	968,894,000	1,085,353,000	+ 12.0
Daily Average	3,670,000	4,205,000	+ 14.6	3,536,000	3,976,000	+ 12.4
TOTAL DEMAND FOR PRODUCTS—						
Motor Fuels:						
Domestic	52,297,000	58,995,000	+ 12.8	440,130,000	493,958,000	+ 12.2
Exports	1,907,000	2,475,000	+ 29.8	18,770,000	16,005,000	— 14.7
Total	54,204,000	61,470,000	+ 13.4	458,900,000	509,963,000	+ 11.1
Aviation Gasoline:						
Domestic	602,000	1,109,000	+ 84.2	4,746,000	7,814,000	+ 64.6
Exports	301,000	483,000	+ 60.5	3,416,000	3,527,000	+ 3.2
Total	903,000	1,592,000	+ 76.3	8,162,000	11,341,000	+ 38.9
Kerosene:						
Domestic	5,173,000	5,624,000	+ 8.7	48,592,000	49,388,000	+ 1.6
Exports	178,000	314,000	+ 76.4	2,926,000	1,626,000	— 44.4
Total	5,351,000	5,938,000	+ 10.9	51,518,000	51,014,000	— 0.9
Gas Oil & Distillate Fuels:						
Domestic	10,439,000	[2]11,670,000	+ 11.8	110,911,000	124,913,000	+ 12.6
Exports	947,000	1,110,000	+ 17.2	15,579,000	11,400,000	— 26.8
Total	11,386,000	12,780,000	+ 12.2	126,490,000	136,313,000	+ 7.8
Residual Fuel Oils:						
Domestic	25,843,000	[3]31,534,000	+ 22.0	245,157,000	276,491,000	+ 12.8
Exports	1,552,000	1,469,000	— 5.3	12,464,000	10,796,000	— 13.4
Total	27,395,000	33,003,000	+ 20.5	257,621,000	287,287,000	+ 11.5
Lubricants:						
Domestic	2,150,000	2,638,000	+ 22.7	17,851,000	23,317,000	+ 30.6
Exports	393,000	580,000	+ 47.6	8,620,000	6,920,000	— 19.7
Total	2,543,000	3,218,000	+ 26.5	26,471,000	30,237,000	+ 14.2
Wax (thousands of pounds):						
Domestic	37,988	53,831	+ 41.7	257,103	398,977	+ 55.2
Exports	11,428	20,101	+ 75.9	159,194	132,653	— 16.7
Total	49,416	73,932	+ 49.6	416,297	531,630	+ 27.7
Coke (short tons):						
Domestic	122,300	147,200	+ 20.4	1,029,400	1,126,900	+ 9.5
Exports	26,900	12,600	— 53.2	200,200	185,100	— 7.5
Total	149,200	159,800	+ 7.1	1,229,600	1,312,000	+ 6.7
Asphalt (short tons):						
Domestic	695,800	798,700	+ 14.8	3,911,700	4,849,300	+ 23.9
Exports	16,900	22,900	+ 35.5	231,600	187,100	— 19.2
Total	712,700	821,600	+ 15.3	4,143,300	5,036,400	+ 21.6
Road Oil:						
Domestic Demand	1,128,000	1,462,000	+ 29.6	6,697,000	7,551,000	+ 12.8
Miscellaneous:						
Domestic	222,000	308,000	+ 38.7	1,579,000	2,591,000	+ 64.1
Exports	42,000	39,000	— 7.1	781,000	442,000	— 43.4
Total	264,000	347,000	+ 31.4	2,360,000	3,033,000	+ 28.5

[1] Partially estimated. [2] Includes 612,000 barrels Diesel bunker oil. [3] Includes 1,[illegible],000 barrels bunker fuel oil.

Gage Goes to Shell Chemical Company

W. P. Gage, manager of Shell Oil Company's development division, has been appointed vice president in charge of manufacturing and technical development for Shell Chemical Company.

He will be located in San Francisco, headquarters for the Shell Chemical Company, and will be primarily concerned with improvements and additions to plant facilities for the production of chemical by-products of petroleum.

Gage started with Shell in 1929 as a junior chemist at the Wood River refinery and two years later was placed in charge of the experimental laboratory. From that time on he served both at the Wood River and Houston refineries in various capacities chiefly related to the development of facilities for the manufacture of new and improved products. In November, 1939, he was called to head the development division of the manufacturing department.

Succeeding as manager of the development division-manufacturing department of Shell Oil Company, is G. C. Cunningham, formerly assistant superintendent at Shell's Houston refinery. A native of Missouri, Cunningham studied chemical engineering at the Missouri School of Mines. He joined Shell in 1924 in the laboratory at Wood River. Since then he has seen service at Shell's New Orleans and Houston refineries and in the head office. He became assistant superintendent at Houston in May, 1940.

Moving up from manager of the gas department at the Houston refinery to succeed Cunningham is Albert Garrison. Born in Arkansas, Garrison studied chemical engineering at the University of Arkansas and joined Shell as a junior chemist in 1929 at Wood River. After serving in various capacities, he was transferred to Houston in 1938 to head the gas department.

Glenn Purcell, senior technologist at the Wood River refinery moves to Houston to fill the position vacated by Garrison. Purcell is a graduate of the University of Oklahoma and has been with Shell at Wood River since 1929.

Frolich Nominated For ACS Presidency

Per K. Frolich, director of Esso Laboratories, chemical division, Standard Oil Development Company, Elizabeth, New Jersey, is among those nominated for the presidency of the American Chemical Society. Voting will be mail with 13 men for consideration.

He is a former chairman of the Division of Petroleum Chemistry, a director of the Division of Rubber Chemistry and for the past two years has been councilor at large.

He joined the staff of Standard Oil Development Company in 1929 after serving on the faculty of Massachusetts Institute of Technology.

Chemical Engineers To Meet in Boston

The annual meeting of the American Institute of Chemical Engineers will be held May 11, 12 and 13 in Boston. This will be the thirty-fourth meeting of the organization.

The Look Box

Independent Refiners Pressed from Two Sides

Refiners currently face several serious problems that have arisen in connection with the defense program, it was pointed out in late November in a statement issued by the Gulf Coast Refiners' Association, over the signature of George Reid, executive secretary.

Prominent among the matters confronting the refiners is the necessity for higher product prices in event the government permits raising of crude postings, according to the statement; while other problems include scarcity and high prices of natural gasoline for blending, scarcity of tetraethyl lead for improving octane rating of gasoline, high tanker rates, and difficulty of purchasing most needed types of crude oils.

The full text of the statement by the organization, composed of independent refiners of the Texas-Louisiana Gulf Coast, is herewith presented:

"Faced with the growing possibility of an increase in crude oil prices, with materially increased prices for natural gasoline used for blending purposes, with allocation and uncertainty of supply of tetraethyl lead for octane requirements, with the inability to purchase the type of crude oils most needed because of proration and the 'yard stick formula' in Texas, and continued high tanker rates, the independent refiner operating in the Gulf Coast refining centers is searching for some measure of relief. These operators are working under recently imposed ceilings on the finished petroleum products to the end that the customary method of asking more for products to off-set increased operating costs cannot be used. It is a confusing condition where every available drop of refining capacity is urgently needed during this national emergency, yet these refiners find in any direction they turn that factors which should contribute to their ability to operate turn out to be bottlenecks.

"The problem of securing proper crude oils for processing by the independent refiners is one of serious importance. These refiners are being called upon to furnish vast quantities of a particular grade of motor fuel for use by the Brtish, as well as to furnish increasing quantities of domestic gasoline in premium grades and other petroleum products. This condition brings about a demand for crude oils of types most suitable for the production of the products required during this emergency.

"It is thought by many refiners that such conditions indicate the necessity for the abandonment of the so-called 'yard stick formula' which the Texas Railroad Commission adopted early this year in lieu of the time tested market demand method of proration. In effect, the so-called 'formula' has actually brought about the necessity of selective buying of crude oils, instead of preventing that practice. Refiners in Texas must now purchase increasing quantities of New Mexico and Louisiana crude oils for refining in Texas plants, and large major company operators in the Eastern Seaboard area must purchase and import increasing quantities of crude from Venezuela and other South American countries. At the same time Texas producers are shutting down their wells 8 days per month in order to comply with proration limitations. Further, because of the lack of proper crudes, and because these crudes are not made available to them, independent refiners on the Gulf Coast cannot operate their plants at capacity although they are under increasing pressure exerted from Washington to process all the crude oil possible.

Crude Prices

"The independent refiner, operating under a recently requested ceiling of 6½ cents for 80 research octane gasoline, looks upon the present nation-wide vigorous campaign to secure higher prices for crude oil with mixed feeling. The refiner realizes that the crude oil producers have been incurring materially increased costs with respect to all cost factors pertinent to drilling and production of oil and he feels that a higher price for crude oil is a reasonable request to make of the price control administration. However, should crude prices be permitted to rise above present levels, the refiner will not be able to operate his plant under present price ceilings for all petroleum products. The refining industry has been requested not to increase any prices without two weeks notice and subsequent consultation with the Office of Price Administration at Washington.

CONVENTIONS

JAN. 12–16	Society of Automotive Engineers, Annual Meeting, Book-Cadillac Hotel, Detroit.
MAR. 2– 5	American Society for Testing Materials, Spring Meeting, Cleveland.
23–25	Western Petroleum Refiners Association, St. Charles Hotel, New Orleans.
23–25	American Society of Mechanical Engineers, Spring Meeting, Houston.
APR. 13–17	American Institute of Mining and Metallurgical Engineers, Cincinnati.
16–17	National Petroleum Association, Semi-Annual Meeting, Cleveland.
21–23	Southwestern Gas Measurement Short Course, University of Oklahoma, Norman.
22–24	Petroleum Industry Electrical Association, Washington-Youree Hotel, Shreveport.
MAY 11–13	American Institute of Chemical Engineers, Boston.
13–15	Natural Gasoline Association of America, Mayo Hotel, Tulsa.
16–23	International Petroleum Exposition, Tulsa.
JUNE 8–11	American Society of Mechanical Engineers, Semi-Annual Meeting, Cleveland.
22–26	American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City.

Therefore, if crude oil prices are permitted to increase, the refiner feels that the price administration group should give concurrent study to the needs for higher finished product prices at the refinery. This is especially important to the refiner in consequence of the recent marked increases in cost of blending agents, in all supplies and materials, and in wages.

"While the refining industry is now securing prices for its products closely paralleling those received during 1937, which was the most recent 'good year' for the industry, it must be borne in mind that in 1937 crude oil prices were somewhat lower than they are today and further, the quality of motor fuels has been greatly improved during the past four years and the cost of producing such modern fuels has been increased. This means that under present price schedules, the refiner is actually realizing less from the processing of crude oil than he was in 1937 when crude prices were lower and further increases in crude oil prices will cause additional hardship.

Natural Gasoline

"The increasing scarcity of natural gasoline coupled with the increased demand for this product used at the refineries in blending motor fuel to meet volatility and other specifications has caused a rapid increase in the price of the various grades produced by the natural gasoline industry.

"It is becoming increasingly difficult to purchase the lighter and less expensive grades of natural gasoline. This product is so priced by its producers that the heavier and less volatile grades bring higher prices, thus when the refiner is forced to purchase the heavier types of natural gasoline, he is also forced to pay a premium for it and at the same time is forced to use it in materially higher percentages to blend his motor fuels. This contributes largely to the increasing cost of producing motor fuels at the refinery for it is often necessary for the refinery to use 25 percent to as high as 35 percent of natural gasoline in order to meet winter specifications. Some of the natural gasoline grades now being used are costing the refiner from 7 cents to 8 cents per gallon and this material is used in increasing proportions in motor fuels which must be marketed under a recently imposed price ceiling of 6½ cents.

"The difficulty faced by the industry in this respect lies in the fact that the lighter grades of natural gasoline and the lighter hydrocarbon liquids produced by the natural gasoline industry are needed in ever increasing quantities by the refining companies for production of 100 octane aviation gasoline. As the demand increases for both the lighter grades for aviation requirements and for the heavier grades for motor gasoline blending purposes, the situation becomes tighter, prices increase, and the refiner finds it increasingly difficult to purchase blending materials, to pay the price asked for them, and to meet specifications of the major purchasing companies.

Octane Rating

"The refining industry is also faced with a shortage of tetraethyl lead which is used for improving octane rating of almost all gasolines. This material has already been placed on an allocation basis with its availability for all customary purposes now uncertain. With this condition prevailing the refiner finds in many instances, that because of the necessity for using larger quantities of the heavier grades of natural gasoline for blending purposes, which in turn require tetraethyl lead to improve the anti-knock rating, he must use a larger lead-dosage in order to meet the octane requirements of the major purchasing companies. Thus, the refinery gasoline and the blending materials used must both be 'leaded-up' to octane specifications to meet needs for the 80 and 81 and 83 research octane gasoline grades. This development, of course, also contributes materially to the cost of producing the better grades of motor fuels.

Transportation

"Tanker rates from Gulf Coast ports to the Eastern Seaboard were pegged in the spring of 1941 at 50 cents per barrel for gasoline and with higher rates for other products ranging upward to 57 cents per barrel. This is virtually twice the average rate for the ten-year period 1929 to 1939 and represents a cost of practically one and one-fourth cents per gallon to move gasoline to the East Coast marketing area. Such freight rates are thought by many in the industry to be 100 percent too high. They place an undue burden on independent refiners who desire to market their products in the Eastern market."

New Orleans Draws 1942 WPRA Meeting

The annual meeting of the Western Petroleum Refiners Association will be held in New Orleans, March 23, 24 and 25. Directors made the selection the latter part of November and committees set to work to prepare programs for the general and technical sessions.

The St. Charles Hotel will be headquarters for the meeting.

Brown Chairman Michigan Engineering Department

Dr. George Granger Brown has been appointed chairman of the department of chemical and metallurgical engineering of the University of Michigan. He will take over administrative duties which Professor Alfred H. White gave up at his request. White will continue on the staff of the school of chemical engineering.

Dr. Alois Cibulka at University of Texas

Dr. Alois Cibulka has joined the staff of the school of petroleum engineering at the University of Texas. He resigned earlier this year as design engineer for Humble Oil & Refining Company at Baytown. Shortly afterward he published his "Design Handbook for Practical Engineers," which has since had wide distribution in the petroleum industry as well as other industries. The price of this book now has been reduced to $5 instead of $10.

The author, whose address is now 2623 Lalado, Austin, Texas, is handling distribution.

Advisory Council on Petroleum Formed

With the formation of the Petroleum Industry Council for National Defense Harold L. Ickes, petroleum coordinator, set up personnel for bringing the whole industry into the part the industry will play in national defense.

The purpose of the organization is to get the best mobilization of the industry's resources and abilities to deal with problems involved in coordination. The council will top all groups already set up by the coordinator but will not supersede any existing committees.

Members of the general district committees also will serve, ex-officio. Regular monthly meetings will be held in Washington. The first session was held December 8, the date having been set when the coordinator sent messages to 66 men asking that they serve on the council.

His telegram of invitation outlined the objectives as follows:

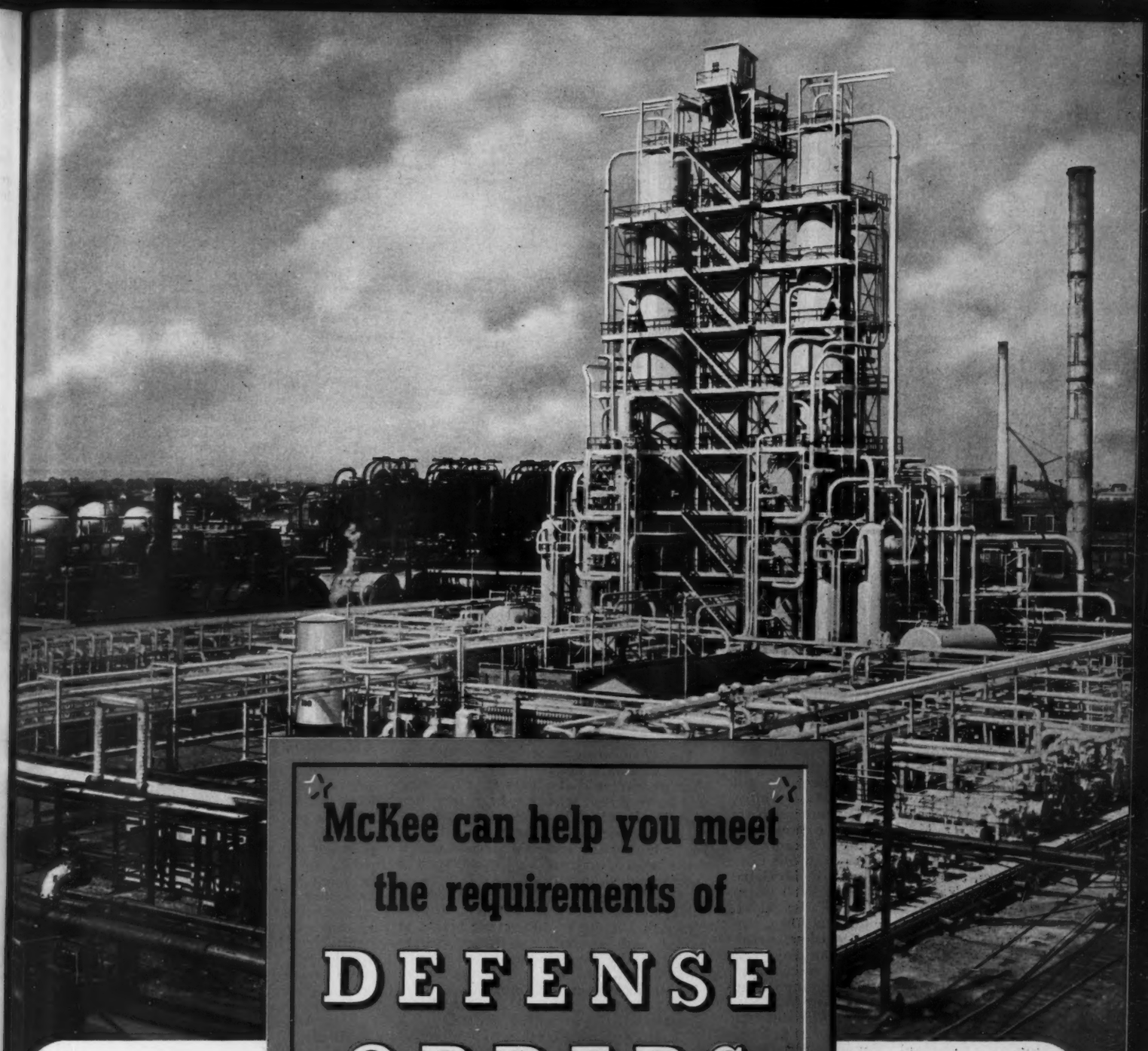
"In order to provide for the fullest cooperation between government and industry in the work of petroleum coordination, I am at this time creating a national council, to be designated the 'Petroleum Industry Council for National Defense.' This council will consist of a membership of both large and small interests in the industry, geographically so distributed as to insure a truly representative group.

"The membership of the present general district committee will be included, ex-officio, in this national council, and together with the individuals I am now appointing, will comprise its full membership. It is the present purpose to hold regular monthly meetings in Washington to consider the problems of petroleum as they currently arise. However, this schedule and related organization and procedural questions will be dealt with at our first meeting, scheduled for December 8 at 10:30 a. m.

"In view of your very extensive knowledge of the petroleum industry and your broad interest in its operations, I should like to have you a member of this Petroleum Industry Council for National Defense, to serve without compensation during the emergency. Your telegraphic acceptance of the appointment and assurance that we may count upon your attendance at the December 8 meeting will be much appreciated."

Those invited to serve included:

T. H. Barton, president, Lion Oil Refining Company, El Dorado, Ark.; C. S. Beesemyer, vice president, Gilmore Oil Company, Los Angeles; Sidney Belither, vice president, Shell Oil Company, San Francisco; M. L. Benedum, president, Benedum-Trees Oil Company, Pittsburgh; Paul G. Blazer, president, Ashland Oil & Refining Company, Ashland, Kentucky; W. R. Boyd, Jr., president, American Petroleum Institute, New York; L. S. Bridwell, president, Bridwell Oil & Gas Company, Wichita Falls; John A. Brown, president, Socony-Vacuum Oil Company, New York; Frank Buttram, president, Independent Petroleum Association of America, Oklahoma City; H. Earl Clack, president, Clack Oil Company, Havre, Montana; R. H. Colley, president, Atlantic Refining Company, Philadelphia; H. D. Collier, president, Standard Oil Company (California), San Francisco; Howard Cowden, presi-



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dent, Consumers Cooperative Association, North Kansas City; Henry M. Dawes, president, Pure Oil Company, Chicago; R. E. Decker, president, National Oil Marketers Association, Detroit; B. E. Devere, president, Independent Refiners Association of California, Los Angeles; H. W. Dodge, vice president, The Texas Company, New York; O. D. Donnell, president, Ohio Oil Company, Findlay, Ohio; J. Frank Drake, president, Gulf Oil Corporation, Pittsburgh; W. S. Farish, president, Standard Oil Company (New Jersey), New York; W. H. Ferguson, vice president, Continental Oil Company, Denver; Jacob France, president, Mid-Continent Petroleum Corporation, Tulsa; Walter S. Hallanan, president, Plymouth Oil Co., Charleston, West Virginia; J. L. Hamon, president, Cox and Hamon, Inc., Dallas; C. L. Henderson, president, Western Petroleum Refiners Association, Wichita.

Also George A. Hill, Jr., president, Houston Oil Company, Houston; Dana Hogan, president, Hogan Petroleum Company, Los Angeles; W. T. Holiday, president, Standard Oil Company of Ohio, Cleveland; Dan Hovey, president, Gulf Coast Refiners Association, Houston; Wm. F. Humphrey, president, Tide Water Associated Oil Company, San Francisco; J. C. Hunter, president, Mid-Continent Oil and Gas Association, Abilene; A. Jacobsen, president, Amerada Petroleum Corporation, New York; C. S. Jones, president, Richfield Oil Corporation, Los Angeles; Roy B. Jones, president, Panhandle Producing & Refining Company, Wichita Falls; W. A. Jones, president, Cities Service Oil Company, New York; J. M. Lovejoy, president, Seaboard Oil Company, New York; B. L. Majewski, vice president, Deep Rock Oil Company, Chicago; A. C. Mattei, president, Honolulu Oil Corporation, San Francisco; C. P. McGaha, president, National Stripper Well Owners Association, Wichita Falls; D. J. Moran, president, Continental Oil Company, Houston; S. B. Mosher, president, Signal Oil & Gas Company, Los Angeles; Henry D. Moyle, vice president, Wasatch Oil and Refining Company, Salt Lake City; Burton W. Musser, general counsel, Utah Oil Refining Company, Salt Lake City; John N. Newton, vice president, Magnolia Petroleum Company, Beaumont; I. A. O'Shaughnessy, president, Globe Oil & Refining Company, Wichita; J. R. Parten, chairman, Premier Oil Refining Company, Houston.

And J. Howard Pew, president, Sun Oil Company, Philadelphia; Frank Phillips, chairman of the board, Phillips Petroleum Company, Bartlesville; E. E. Pyles, vice president, Hancock Oil Company, Long Beach; E. B. Reeser, president, Barnsdall Oil Company, Tulsa; Will J. Reid, president, Hancock Oil Company, Long Beach; W. S. S. Rodgers, president, The Texas Company, New York; Charles F. Roeser, Roeser and Pendleton, Fort Worth; E. G. Seubert, president, Standard Oil Company (Indiana), Chicago; R. S. Shannon, president, Minnelusa Oil Corporation, Denver; H. F. Sinclair, chairman, Consolidated Oil Corporation, New York; W. G. Skelly, president, Skelly Oil Company, Tulsa; W. L. Stewart, vice president, Union Oil Company, Los Angeles; N. H. Weber, president National Petroleum Association, Chicago; Reese H. Taylor, president, Union Oil Company, Los Angeles; Lawrence Vander Leck, president, Oil Producers Agency, Los Angeles; R. Van der Woude, president, Shell Union Oil Corporation, New York; E. V. Weber, president, Ohio Petroleum Marketers Association, Cincinnati; A. L. Weil, Los Angeles; H. C. Wiess, president, Humble Oil & Refining Company, Houston, and Robert E. Wilson, president, Pan-American Petroleum & Transport Company, New York.

Emergency Plans For 100 Octane Gasoline

Methods for immediate expansion of output of 100-octane aviation gasoline have been outlined in the office of the petroleum coordinator. His long-range program calls for expansion of capacity of this fuel to 126,000 barrels daily during 1943. Present capacity is around 40,000 barrels daily.

Since considerable plant expansion will be required in meeting the top figure and there is immediate need for higher output, the plan for immediate expansion was set forth as part of the program to be completed in 1943. The program follows:

"1. Immediate and expeditious undertaking of additional plant construction, designed to boost production from an estimated 44,000 barrels January 1, 1942, to approximately 126,000 barrels daily by sometime in 1943. The government can aid tremendously in this program, by:

"(a) Allocating materials and supplies so as to assure deliveries promptly and thus guarantee that plants now building will be ready on schedule, or, if possible, ahead of schedule. Tonnage requirements are not large. The principal need is for highly fabricated materials which must be programmed well in advance in specialized shops.

"(b) Authorizing the Defense Supplies Corporation to contract to purchase the output of 100-octane plants at prices and in sufficient quantities to amortize the investment in the plants. Contracts would be for a minimum period of three years or longer.

"(c) Providing for Defense Plant Corporation loans where needed.

"2. Immediate adoption of temporary measures to meet estimated requirements pending the time when new plants are finished. These include:

"(a) Permitting use of more tetraethyl lead in Army and Navy aviation gasoline. This would bring an estimated 20 percent increase in productive capacity by freeing other components.

"(b) Using 91-octane gasoline, instead of 100-octane, in Army training planes.

"(c) Improving the blending methods.

"(d) Using more available materials for the rarer blending agents when possible.

"(e) Discontinuing use of high-octane blending stocks for non-defense purposes. For example, some high-octane blending agents are used in 73-octane unleaded fuels.

"(f) Increasing the capacity of existing plants, by supplying additional charging stock, providing for minor processing changes and diverting to 100-octane manufacture certain complicated processes now used to make lower-octane fuel."

In commenting on the program the petroleum coordinator said:

"It is our goal to see to it that the American planes coming off the assembly lines are given the finest fuel in the world, a fuel that will enable them to exercise air superiority. In addition we have taken up the obligation of supplying 100-octane gasoline to the democratic nations for the fleets sweeping Hitlerism from the skies.

"To meet the demands for this highly prized fuel will be no easy job. There should be no delusion about that. We have to move fast and effectively. New refineries must be built. Others must be expanded. Ample raw materials must be obtained. New raw materials sources must be developed. We will have to make adjustments in the make-up of the product without injuring its quality.

"In the face of difficulties in obtaining materials and equipment, the job is one of the toughest the industry faces. But the integrated program we have prepared should go a long way toward meeting the problem. I am confident that American ingenuity which developed this fuel in the first place, coupled with the initiative and drive shown by the oil industry in emergencies, will make it possible to achieve our goal."

In addition to eight plants now under construction, priorities have been assured for 18 additional plants. These, by different processes, will contribute to the capacity for 100-octane aviation gasoline.

Ethyl Gasoline Corporation Allocates Limited Lead Supply

Limited supplies of raw materials, coupled with increasing consumption, have led Ethyl Gasoline Corporation to adopt a policy of allocating supplies of tetraethyl lead. The company, although pointing out that its manufacturing capacity to produce the anti-knock agent is much in excess of present demands, announces that "for these reasons it becomes necessary to allocate our product among our customers on as fair and equitable a basis as seems possible. Accordingly, effective immediately, we have adopted the following policy, subject to change from time to time as the foregoing conditions necessitate:

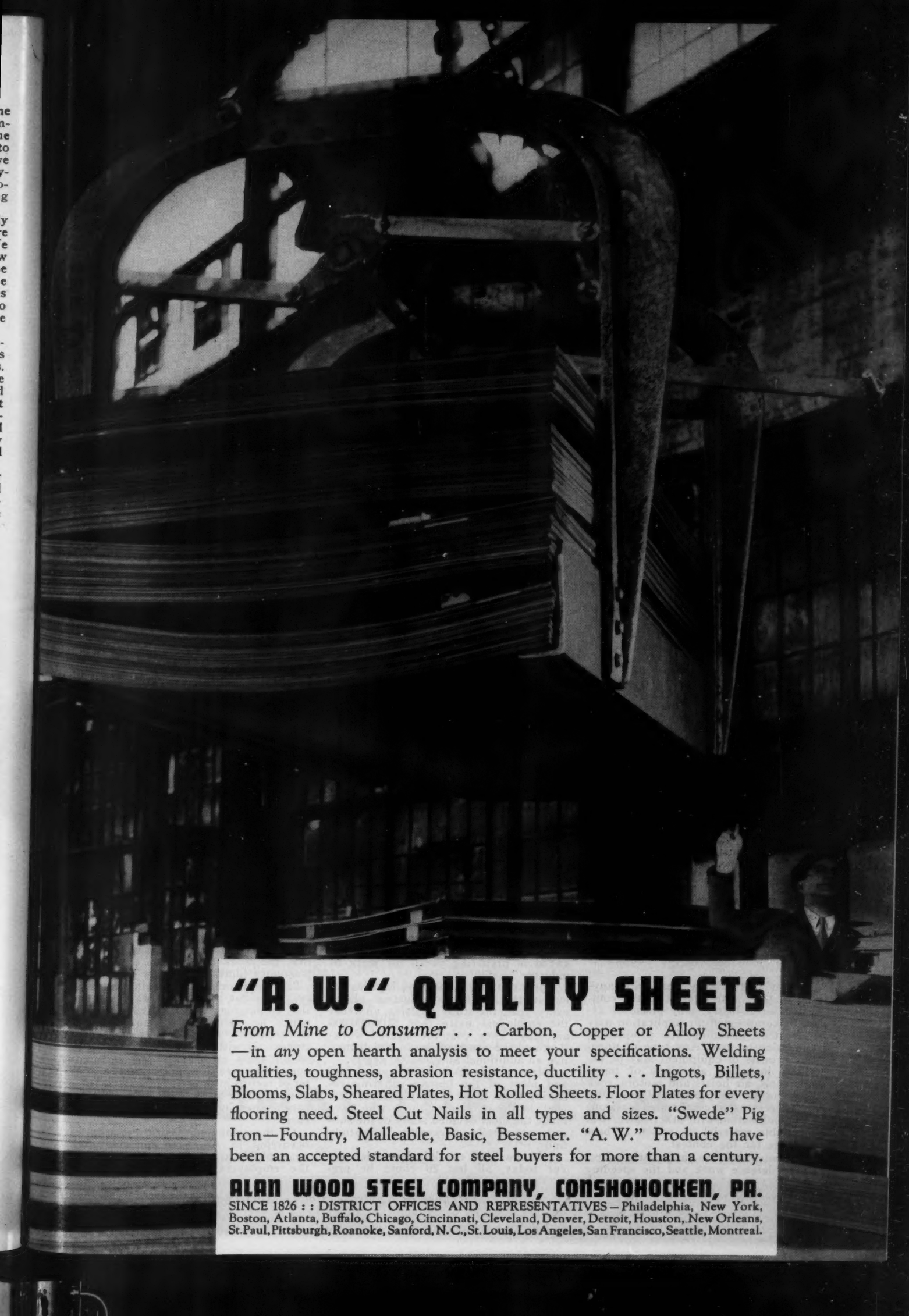
"(1) All orders now in our hands will be filled,

"(2) All future orders for aviation fluid and all direct orders for U. S. and foreign governments for defense purposes will have priority fulfillment,

"(3) All future orders from our customers necessary to fill requirements of both the U. S. and approved foreign armed forces, certified thereto by the customer, will also have priority in fulfillment,

"(4) All other future orders until further notice will be allocated, if necessary, on the basis of a percentage (same percentage for all customers) of each customer's purchase during the year beginning November 15, 1940, distributed by us as nearly as possible to correspond to the distribution for the 12 months in question."

Customers ordering at frequent intervals will be allocated in any one month a quantity of tetraethyl lead approximately equal to one third their purchases during the three-month period beginning November 15, 1940, and multiplied by the percentage described in (4) above. Allocations for succeeding quarterly periods will be made on the same basis. Occasional customers will



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have new orders filled only after lapse of a time corresponding to the average period between orders during the year beginning November 15, 1940, corrected for the percentage mentioned above. New customers who did not purchase during the three-month period beginning November 15, 1940, will be allocated on an equivalent basis as in (1) or (2) above as far as possible. Where the methods of allocation threaten undue hardship, special consideration will be given.

Ethyl Gasoline Corporation expects to complete early next year its $2,400,000 plant at Baton Rouge, Louisiana, to manufacture hydrochloric acid from salt and sulphuric acid. The hydrochloric acid produced will be used in place of chlorine to make tetraethyl lead and will thus release about 1,000,000 cubic feet per day of chlorine for national defense needs.

Compressed Air Institute Announces Prize Contest

The Compressed Air Institute has started a nation-wide contest for industry. The contest is to continue for six months, closing June 1, 1942. Fourteen cash awards will be given. These comprise a first prize of $100; three $50 prizes and ten of $25, and as many additional awards of $25 as there shall be contestants who submit material acceptable for use in technical journals.

Virtually no restrictions are placed upon the eligibility of contestants. Nor is the subject matter limited other than it be concerned with some use or phase of compressed air. The contest is open to any employe of any organization using or associated with compressed air in any department. The only exceptions are executives of companies comprising the Institute.

Institute members state they anticipate entries from a wide range of contestants since compressed air is used industrially in so many ways. Men with technical training will be interested because the subject is well suited for such discussion. On the other hand thousands of workers who use pneumatic equipment of some kind every day, will want to tell what they know about it. The latter group need have no hesitancy in entering the contest since the rules explicitly state, "skill in writing, grammatical construction or excellence in English will have no particular weight in awarding prizes."

Articles submitted are to be judged according to the usefulness to the industry of the idea submitted; the originality of the text; the value of the text to the greatest number of industries and the technical accuracy and completeness with which the subject is treated.

Subject matter may deal with anything of particular interest to the compressed air industry. Any phase or aspect of compressed air application may be treated, including its production, tranmission or uses. Any type of pneumatic process or equipment may be described, including all kinds of pneumatic tools, air hoists and motors, rock drills, and air compressors of any type. Any process using compressed air alone or in combination with other power will be suitable material on which to base an article for the contest.

Any entry which is particularly adaptable to defense work and the speeding up of the defense program, whether a prize winer or not, will be brought to the attention of the proper government agency, with full credit given the contestant.

Members of the Institute's educational committee, under which the contest is being held, include: Chairman, H. H. Miller, Worthington Pump and Machinery Corporation; H. P. Bailey, Rotor Tool Company, J. W. Haddock, Sullivan Machinery Company; M. L. McCormack, Ingersoll-Rand Company; P. F. Stauffer, Fuller Company; T. P. Harris, Chicago Pneumatic Tool Company, and J. S. Tatman, Roots-Connersville Blower Corporation. They request that all contest presentations be mailed to C. C. Rohrbach, secretary, compressed Air Institute, 90 West Street, New York.

Most Eye Injuries Are Avoidable

Ninety-eight percent of the eye injuries which occur in American industries at a rate of 1,000 a day and represent an annual loss of $200,000,000 are wholly unnecessary, according to a study sponsored by the National Society for the Prevention of Blindness and just issued by the Columbia University Press and prepared by the late Louis Resnick, staff member of the society for 20 years. His report, which was completed three days before his death in March, 1941, is based upon two decades of personal observation in workshops throughout the country. It contains a complete summary of eye hazards in American industry. A pioneer in the field of industrial safety, Resnick was the first editor of National Safety News and at the time of his death was industrial relations director of the National Society for the Prevention of Blindness.

"Conservation of the vision of American workmen is as vital to national defense as is the building of armament and the training of men to use defense equipment," Lewis H. Carris, director emeritus of the society, points out in a preface to the study. "This volume not only lays bare the eye hazards present in industries and occupations of all sorts, but also reports on the measures that may be taken to eliminate these hazards and to guard workers against those which cannot be eliminated. It is the hope of the sponsors of this volume that it will serve not only as a handbook for safety engineers, safety inspectors, and all others engaged in accident prevention generally and sight conservation in particular, but also as a textbook for engineering schools, vocational training authorities, and all others engaged in preparing youth for work in industry."

Approximately 300,000 eye injuries occur in this country's industrial plants every year, the study explains, and cost the employers more than $100,000,000 annually. They cost the injured workmen and the communities in which they live an additional $100,000,000 yearly.

"Most of this $200,000,000 annual loss and most of the human suffering resulting from these eye injuries—98 percent, in the opinion of those who have made the most detailed study of the subject—are wholly unnecessary," the study finds.

"Of the 1,000 eye injuries which occur today, all but 20 could be prevented. Conditions observed during the past 20 years in American factories, railroads, and other work places lead inevitably to the conviction that accidents are not inherent in industry, and that the dividends on investments in accident prevention may be proportionately greater than the dividends on the primary business of an industry.

"There is no need for the blinding of workers in American industry. The industrial accident and disease hazards affecting the eyes are commonly known. Methods of eliminating these hazards or of protecting workers against them have been demonstrated. Devices which provide protection against almost every type of eye accident are now available.

"There are in the United States more than 80,000 persons who have lost the sight of one eye as a result of industrial hazards and close to 8,000 who have lost permanently the sight of both eyes as a result of these accidents. To this total there is probably added each year 1,000 more who lose the sight of one eye and a hundred or more persons who lose the sight of both eyes as the result of occupational hazards.

"The number of men and women who have lost permanently part of the vision of one eye or of both eyes as the result of industrial accident or health hazards undoubtedly runs into hundreds of thousands, and this total is augmented each year by a number probably in excess of 10,000.

"These are conservative estimates even if it is assumed that the records on which they are based represent a complete reporting of industrial eye injuries. We know, however, that the injuries reported are only a part of the total number of eye injuries which actually occur. In many instances the injured worker does not know he is entitled to compensation, and no one enlightens him.

"Often the seriousness of an eye injury or the fact that it has or will result in permanent loss of vision does not become apparent until long after the injury has occurred, and in many such cases, for one reason or another, no official record of the accident is made. In still other cases the worker is more concerned about the security of his job than in possibly compensation for an injury, and so he does not press his claim for compensation.

"More serious than all the foregoing among the factors contributing to the inadequacy of official records of eye injuries is the rapidly spreading use in industry of poisonous chemicals and other deleterious materials which cause damage to the eyes. In many instances neither the workman whose eyes have been affected nor his physician knows that the worker has been exposed to poisonous fumes, liquids, or dusts.

"In many other cases damage to the eyes develops after the worker has left the employment of the company in which he, knowingly or unknowingly, worked with or near poisonous substances. In either event the true cause of blindness or of other serious damage to the eyes does not become a matter of record in the state industrial commission or in any other source of data concerning industrial injury or diseases."

Of the estimated 300,000 eye injuries occurring in American industry each year, 60,000 are compensable, and cost the employers more than $20,000,000

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THE Cotton Valley Recycling Plant is the largest ever built in this country. It is capable of handling 150,000,000 cubic feet of distillate-laden gas per day. From this it can produce 11,300 barrels of distillate, 2,500 barrels of butanes, and 650 barrels of isopentane. After recovery of liquids, the gas is pumped back into those wells that offer the best means of maintaining pressure.

Recycling at Cotton Valley was made possible by an agreement between operators and royalty owners, which in turn was incorporated in an order of the Louisiana Department of Conservation. Thus the total content of two distillate-bearing sands became available for recovery through one plant under common operation. This is the first venture of its kind on record and will serve as a model for others to follow.

Cotton Valley used hundreds of tons of Seamless pipe of all sizes from ¼" to 24" O.D. Careful selection of the types of steel best fitted to meet widely varying conditions of heat and corrosion was absolutely necessary. It is significant, then, that all the pipe for the plant proper was furnished by NATIONAL Tube Company.

COTTON VALLEY RECYCLING PLANT

Cotton Valley Operator's Committee

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UNITED STATES STEEL

annually for compensation and medical care, Resnick's study reveals.

Accepting the ratio of hidden or indirect costs of industrial accidents, to direct costs of compensation as four to one, the total annual cost of compensable eye accidents amount to $100,000,000, according to the report, which adds that all or most of this sum is ultimately paid by the consumer, the public at large.

"Some further idea of the huge financial loss resulting to employers and employes from preventable eye injuries lies in the fact that eye injuries lead to the loss of more than 53,000,000 manhours of work yearly," the study continues.

"Little progress has been made in bringing to workmen a realization of what accidents cost them in lowered earning capacity and of the money saving they can make by doing their part in safeguarding their eyes. Few workmen, for example, realize that the maximum compensation for total loss of vision of one eye is less than $2,000 in most states, and as low as $1,000 in some.

"How many American workmen would be willing to sell both eyes for $6,000 or less, the maximum compensation payable for loss of sight of both eyes in a majority of states? Few workmen realize that they are risking a 33⅓ percent cut in salary for the rest of their lives every time they risk an eye injury. In the most liberal states the maximum compensation paid for total loss of vision is two-thirds of the wage received by the injured workman at the time of the accident. In some states, as in Oregon, the maximum compensation for total loss of vision is as low as $30 a month for life.

"Practically all the financial loss and the human suffering resulting from the blinding of industrial workers could be averted by the cooperation of employers and employes in the utilization of demonstrated methods of preventing accidents and diseases. Not only would these losses be averted but also efficiency and the earnings of both employers and employes would be substantially increased if all industry did what is being done successfully in a few plants in America to prevent eye injuries.

"The obligation to put into effect the methods, devices, and practices which experience has demonstrated to be successful in protecting the eyes of workers belongs to many groups. It is an obligation first of all on the owners and managers of industry and on all their executives and sub-executives. It is a responsibility of employes individually and collectively through their labor union and other organizations concerned with the health and welfare of workers.

"It is an obligation of government administrators—federal, state, municipal, and county alike. It is an obligation of public and private health and welfare agencies which have any contact either with industry or with industrial workers. It is most directly the responsibility of all those professionally concerned with or having an opportunity for the protection of eyes and of general health, including safety engineers, safety inspectors, industrial physicians, ophthalmologists, general physicians, surgeons, nurses, and local sight conservation agencies."

Washington Roundup

PERMANENT organization of the Petroleum Industry Council for National Defense was completed in Washington December 8 with selection of an executive committee and election of William R. Boyd, Jr., president of the American Petroleum Institute, as chairman of both the council and its executive committee. The council was named November 28 by Harold L. Ickes, Petroleum Coordinator, who asked 68 members of the industry to meet in Washington.

The meeting December 8 heard the petroleum coordinator outline objectives and went into executive session with no representative of the government present. Permanent organization was affected promptly. A secretary will be named and headquarters maintained in Washington. Meetings will be held each month.

Members of the executive committee are: John A. Brown, Socony-Vacuum Oil Company, New York; Frank Buttram, Independent Petroleum Association of America, Oklahoma City; H. D. Collier, Standard Oil Company of California, San Francisco; O. D. Donnell, Ohio Oil Company, Findlay; J. Frank Drake, Gulf Oil Corporation, Pittsburgh; W. S. Farish, Standard Oil Company of New Jersey; W. H. Ferguson, Continental Oil Company, Denver; George A. Hill, Jr., Houston Oil Company, Houston; William F. Humphrey, Tide Water Associated Oil Company, San Francisco; J. C. Hunter, Mid-Continent Oil & Gas Association, Abilene, Texas; W. A. Jones, Cities Service Oil Company, New York; B. L. Majewsky, Deep Rock Oil Corporation, Chicago; Henry D. Moyle, Wasatch Oil & Refining Company, Salt Lake City; J. R. Parten, Woodley Petroleum Company, Houston; I. A. O'Shagnessy, Globe Oil & Refining Company, Wichita Kansas; J. Howard Pew, Sun Oil Company, Philadelphia; Frank Phillips, Phillips Petroleum Company, Bartlesville; E. E. Pyles, Hancock Oil Company, Long Beach, California; W. S. S. Rodgers, The Texas Company, New York; Charles F. Roeser, Roeser & Pendleton, Fort Worth; E. G. Seubert, Standard Oil Company (Indiana), Chicago; H. F. Sinclair, Consolidated Oil Corporation, New York; Lawrence Vander Leck, Oil Producers Agency, Los Angeles; R. Van der Woude, Shell Union Oil Company, New York; A. L. Weil, Los Angeles.

Among the things given to the group at its first meeting was the statement by the petroleum coordinator that tankers recently restored to Atlantic-Gulf coastwise service might be needed for war service with the beginning of war with Japan.

During the week between naming of the council and its organization there had been complaints from some elements in the industry that the men selected were not satisfactory from several viewpoints, one being that important oil states had been ignored in the selection.

There were protests from independent producers over the attitude of some of the agencies in Washington regarding procedure in gaining higher prices for crude oil. Also officials of the Independent Petroleum Association of America protests against the attitude in Washington toward officials of these associations.

Prices

Trade associations have been "frozen out" of all negotiations with the Office of Price Administration on the fixing of ceilings, and members of such organizations are resentful of the refusal of Price Administrator Leon Henderson to deal with the trade bodies to which they look for representation and protection in Washington.

The situation was disclosed last week in a letter by Frank Buttram, president of the Independent Petroleum Association, protesting Henderson's refusal to discuss the crude situation with him on the ground that "it is not our policy to deal with associations on prices."

In his letter, Buttram detailed the difficulties he had encountered in seeking conferences with the OPA chieftain, and said that after a week's futile effort to get a hearing he had returned to Oklahoma.

"I am sorry that you take the position that our people may not associate together for the purpose of discussing the price question with you or the members of your staff," he wrote Henderson. Buttram pointed out the impossibility, because of the time and expense involved, of all the members of the oil industry visiting Washington to discuss price problems with Henderson.

"You and your staff will need information known now only to those in the industry," he argued. "If the information and data are really desired, why should these be refused when jointly presented by individuals uniting in responsible groups?"

OPA officials admitted that they would not discuss price matters with association representatives, but explained that their position had been taken because of the anti-trust laws. They pointed out that it would be in violation of those laws for an association to work collectively on matters of prices, but at the same time contended it would be difficult to work with associations because the industry representatives would have to be checking back continuously with their individual members. At the same time, it was insisted, representatives of both small and large interests are members of the industry panels which are set up and an industry as a whole is given every opportunity to present its views at the meetings on prices.

Department of Justice Officials agreed with the OPA's position, saying that they would "frown upon" efforts of trade associations to talk prices with the Henderson agency.

Although enforcement of the anti-trust laws has been directed along new lines required by the defense program, they said, it is not considered advisable to permit trade associations to participate as such in the consideration of any matters which might deal with prices, restraint of trade or other activities prohibited by the statutes.

They pointed out that while Coordi-

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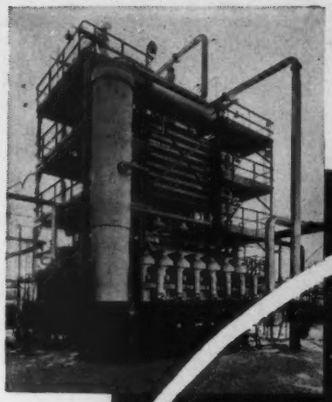

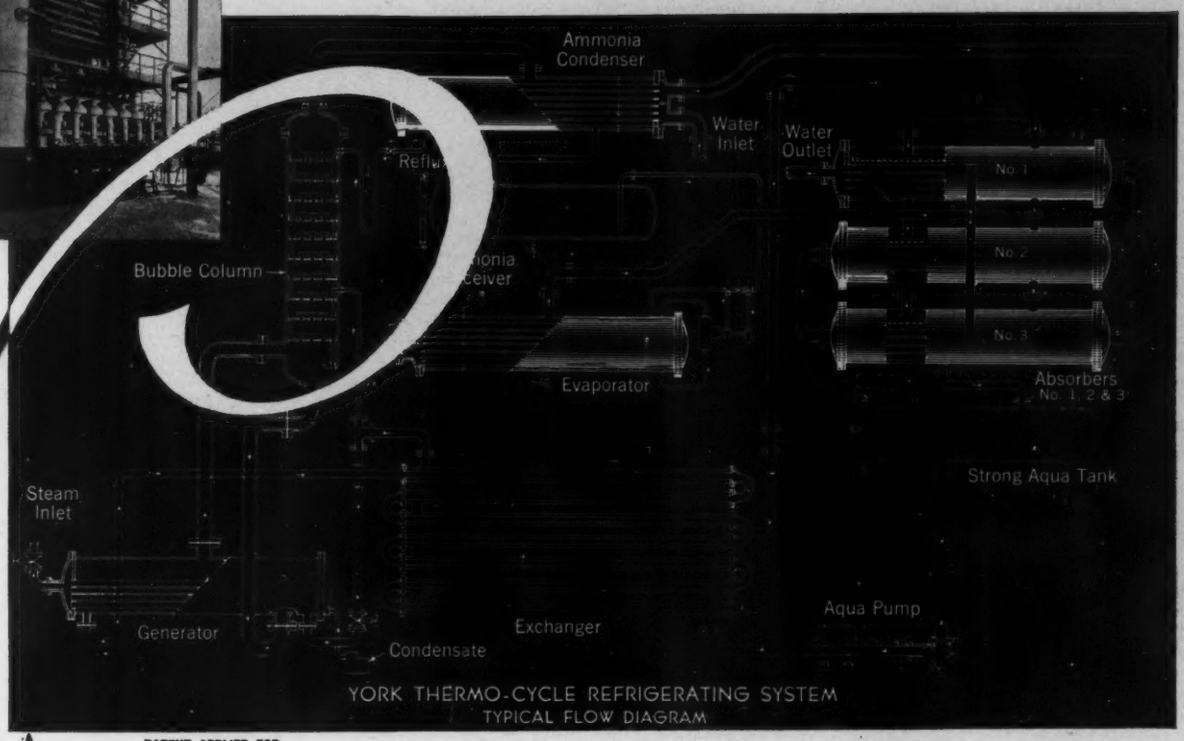

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nator Ickes is submitting his recommendations to the department for clearance even he does not deal with the industry's associations but directs his recommendations to the industry, or a particular branch thereof, as a whole.

The price situation also continued to receive attention in Congress, Representative Frank Carlson (Rep.) of Kansas, declaring in the House, December 4, that an "alarming" drainage of storage reserves is taking place in his state as a result of continued low prices which have discouraged wildcatting. Citing figures showing production declines in a number of states, Carlson declared "There is no doubt in my mind but what the recent freezing of crude oil prices in the Mid-Continent region and the other oil producing areas by Leon Henderson, of the Office of Price Administration, is largely responsible for this reduction.

"Our national defense program has been predicated upon an adequate domestic supply of petroleum production, therefore it is urgent that immediate action be taken to alleviate this condition," he said.

Carlson pointed out that in the past few months refinery gasoline prices have increased 2 or 3 cents per gallon, and told the House that while the producers "are a patriotic group and individually would give liberally of their substance for the defense of our country, I do not believe they should be required to sell their product under a market ceiling when the refiners and distributors were allowed recent increases." If the industry had not been put under government control, he asserted, the present situation would not have arisen and a natural increase in the general price level of the country would have carried through in the oil industry, raising crude prices sufficiently to care for increased costs.

Aviation Gasoline

Top priorities were secured during the week for five more plants to produce 100-octane aviation gasoline or its components, and in addition, it was announced by Coordinator Ickes, high ratings were obtained for materials to be used in the construction of facilities for the manufacture of aviation and other special lubricating oils.

The facilities for which preferences were secured under the aviation gasoline and oil expansion program included 100-octane plants to be constructed by Cities Service Company at East Chicago, Indiana; Gulf Oil Corporation at Port Arthur, and Sinclair Refining Company at Houston; a boiler plant to power a 100-octane refinery, to be built by Panhandle Power & Light Company at Borger, Texas; an isobutane plant of Warren Petroleum Company at Tulsa; a pilot plant of Shell Oil Company at Houston; an aviation lubricating oil plant of Sinclair Refining Company at Houston, and aviation and special lubricating oil plants of Sun Oil Company at Marcus Hook, and Standard Oil of California at Richmond.

A formal recommendation proposing to refiners that hereafter all grades of aviation gasoline of 85-octane number or less be produced by addition of tetraethyl lead to a clear gasoline base stock having an octane number not greater than 67, was announced December 5 by Deputy Coordinator Davies.

The recommendation was a supplement to an earlier proposal asking the industry to discontinue the use of certain vitally essential blending agents of a petroleum origin for other than the manufacture of 100-octane gasoline.

The new order will have the effect, Davies explained, of freeing the better base stocks for use only in the manufacture of 100- or 91-octane aviation gasoline. A considerable quantity of the better stocks, particularly 73-octane clear, are being used now in the production of aviation gasoline for small planes of little defense significance, it was pointed out, and the needs for this type of use can be met by using lead in place of components necessary for the 100-octane product.

Tanker Fleet

The American tanker fleet, including the 62 vessels now being built under private contract for individual operators, 141 already scheduled and building under the Maritime Commission's program, and the 360 now in operation will total 563 oil carriers within approximately two years. The war crisis and the Maritime Commission's policy of rebuilding the American merchant marine to occupy a dominant post-war position are responsible for the vast tanker construction program which will produce 203 new tankers of 2,250,000 gross tons by December 31, 1943, or soon thereafter. The tankers now scheduled for construction will cost approximately $400,000,000, will have a total gross tonnage of 1,620,000 tons and a total capacity of approximately 900,000,000 gallons. The tankers planned by private interests will run to another 614,550 gross tons.

As a further move to meet the emergency occasioned by tanker shortages and to stop the gap until more tankers could come off the ways, the commission authorized the construction of 15 concrete bulk cargo barges, designs for which have been prepared and the contracts for the construction of which have been awarded.

Seventeen American tankers loaned to the British were returned to their owners during November, three were to be turned back this week and two more will be released on the completion of present voyages, making up the total of 40 vessels which the British agreed to relinquish, Coordinator Ickes announced during the week.

With the exception of the *J. A. Moffett* of Standard Oil of California, turned back at Providence, R. I., The Texas Company's *Pennsylvania,* turned back at Port Arthur, and Pure Oil's *2X W. E. Hutton,* returned at Smith Bluff, Texas, all of the ships released last month returned at New York, as follows: *Birkenhead,* Socony-Vacuum; *District of Columbia, Richmond* and *W. S. Miller,* Standard Oil of California; *Frank G. Drum,* Tide Water Associated; *Gulf Breeze* and *Gulfland,* Gulf Oil Company; *Hadnot,* Cities Service; *Pan Georgia,* National Bulk Carriers; *Arkansas,* The Texas Company; *Utacarbon,* Union Oil Company; *Dilworth,* Paco Tankers, Inc.; *J. Fletcher Farrell,* Sinclair Refining and *L. L. Abshire,* Sabine Transportation.

The ships to be returned this week were identified by Ickes as the *Pan Carolina* of National Bulk Carriers and The Texas Company's *Illinois* and *Mississippi.*

Eastern Stocks

East Coast stocks continued to mount during the week ended November 29, reaching a total of 66,929,000 barrels on that date, 505,000 barrels more than on November 22 and 7,036,000 barrels more than on November 30, 1940, it was disclosed by the weekly report of the OPC.

The report showed that the deficiency in heavy fuel oils as compared with a year ago has been wiped out and the 12,539,000 barrels on hand November 29 was 27,000 barrels above the November 30, 1940, figure.

Only in crude oil do stocks remain under 1940 levels, the 12,863,000 barrels reported being short by 627,000 barrels. Gasoline stocks of 19,435,000 barrels were 2,026,000 barrels above last year, and light heating oil inventories of 22,092,000 barrels were 5,610,000 barrels above. The steady decline in the use of railroad tanks cars to bring oil to the East Coast areas which began after announcement that tankers would be returned from the British shuttle service brought the number moved during the week ended November 29 to 3,065, a daily average of 438 cars and 98,550 barrels comparing with 445 cars and 100,125 barrels in the preceding week.

Shipments by companies were reported as follows: Atlanta Refining, 392 cars; Cities Service, 142; Gulf, 205; Pan-American, 163; Pure, 58; Shell, 231; Sinclair Refining, 440; Socony-Vacuum, 104; Standard of Kentucky, 61; Standard of New Jersey, 858; Sun, 18; Texas, 164, and Tide Water Associated, 229.

Taxes

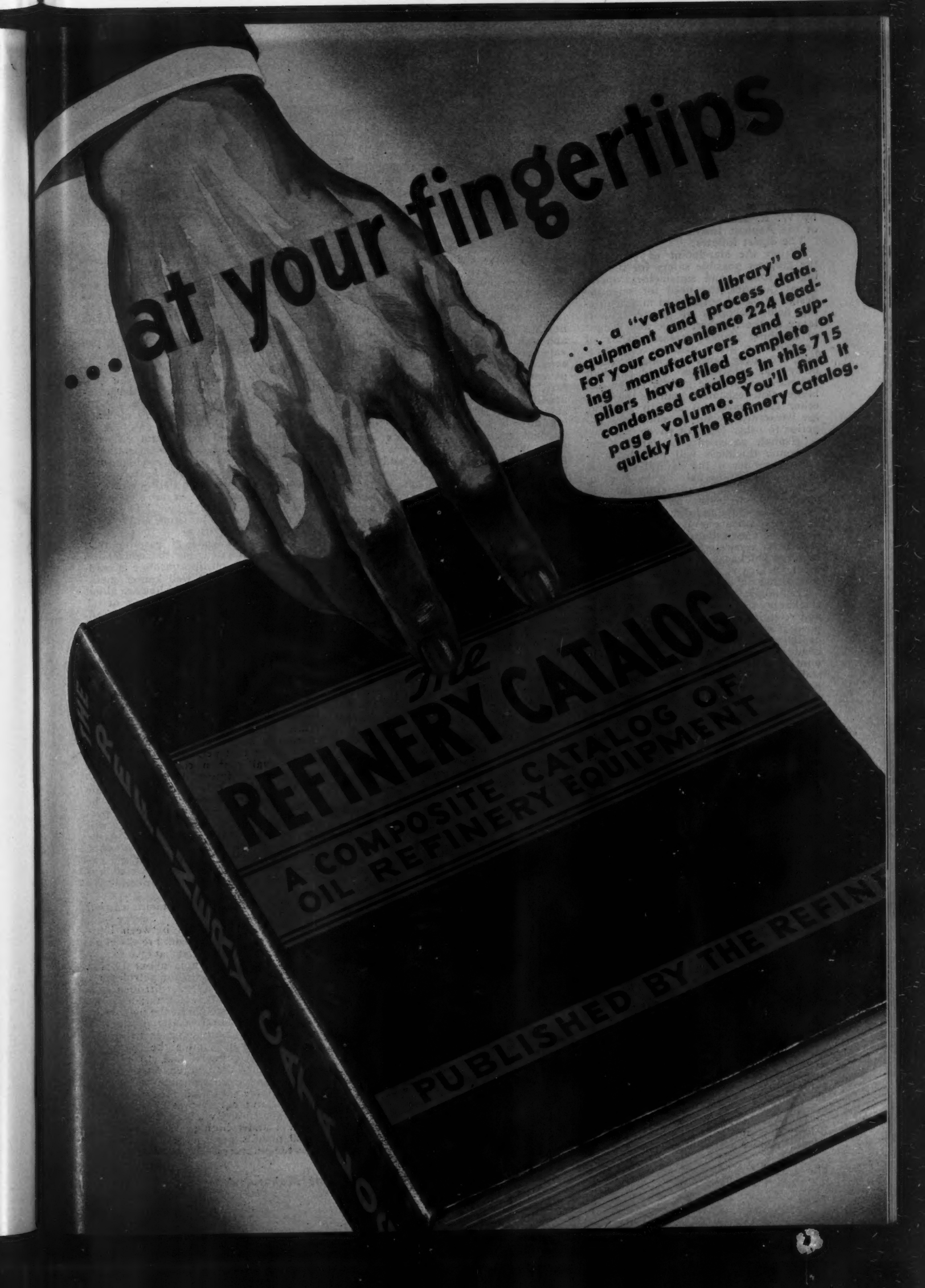
Premature disclosure that the Treasury was seeking a 15-percent tax on salaries and wages, to be collected at the source, and the opposition immediately voiced in Congress to such a heavy levy may force Secretary Morgenthau to abandon that plan in favor of some less drastic method of raising the money the government needs.

As a possible substitute, there are indications Treasury experts are weighing a plan to take 15 percent of earnings, but with part of the levy to be in the form of an involuntary loan, to be invested in defense bonds which would not be payable until the end of the emergency, when they would act as a cushion during the period of transition from a war to a peace economy.

Administration officials are convinced that only by taking a large slice of the increased national income will it be possible to avoid inflation as a result of dwindling supplies of non-essential civilian goods and rapidly increasing earnings.

Sales of defense bonds, originally planned for that purpose, have so far been disappointing, only about $1,775,000,000 having been secured, and there is a growing feeling that stronger methods will have to be adopted to increase sales to the figures planned by the Treasury.

Under the plan said now to be in course of development, employers would be required to withhold a specified percentage from the pay envelopes of their workers. Part of the sum withheld would go for taxes and the rest would be invested in defense stamps, which would be exchanged for bonds as the amounts accumulated. The bonds would be turned over to the individual employes, but they would not be able to cash them until after the end of the emergency.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Data Released on Asphalt Runways

The first release of information from the Asphalt Data and Economics committee of the Western Petroleum Refiners Association, has been issued. It consists of a digest of an article on scientific design of runway pavement by W. R. Macatee, managing director of the Asphalt Institute.

The digest follows:

"From the standpoint of providing the greatest possible safety for the flying personnel, and satisfactory operational facilities, the need for scientific design of paved portions of military flying fields becomes of greater importance as the number, value and weight of bombing planes increase. Safety of personnel is given primary consideration, even over items of economy, durability and construction speed. Asphalt surfaces can provide greater safety and higher skid-resistance qualities than any other type pavement and in addition, are structurally and economically superior to other types of pavement.

"Asphalt pavements of rational and economic thickness will provide satisfactory service if the natural subgrade or the foundation built-up by hauling in improved soil is sufficiently thick in conjunction with the pavement thickness to distribute and diminish the maximum unit surface stresses to intensities below the elastic limits of the subgrade soil in its weakest condition. Thus the required thickness of the asphalt pavement surface is directly related to the supporting value of the subgrade.

"Economic design of the pavement thickness therefore requires accurate and scientific determinations of the supporting values of the subgrades by acceptable bearing test methods, under conditions representing the soil in its poorest condition, and representing the soil conditions after pavement is in place.

"While the heavy bombers may exert the same unit pressure on the surface due to their larger tires as the lighter planes with their smaller tires, the greater total load applied to the runway by the vastly heavier bomber must be considered. Even though identical unit surface stresses may occur, the supporting value of the soil must be greater for the heavier bomber, since it is shown by comprehensive and accurate tests that "for any given deflection, the unit load supporting value of a cohesive soil bears a direct relationship to the size of the loaded area.

"Pavements for bomber fields should be designed on the basis of bombers having 200,000 pounds gross weights, and 1200 square inch tire-imprint area (per main wheel). With these values, and assuming subgrade load ratings for this area of 60 pounds per square inch, the required pavement thickness to support 90-pound unit wheel loads (with a suitable factor of safety) is slightly less than three inches. This should be the minimum thickness even with soils having over 60 pounds per square inch subgrade rating to provide (a) the necessary waterproofing to insure maintenance of the subgrade support value under all weather conditions; (b) adequate lateral stability to prevent abrasion; and (c) a smooth surface of nonskid character which will shed water quickly.

"When subgrade support values are below 60 pounds per square inch it is generally more desirable and economical to increase the subgrade support value by hauling in better local materials, than to increase pavement thickness to sustain given loads. If, however, the cost of increasing the support-value of the underlying soil is greater than the expense of increasing the pavement section, it obviously indicates that a thicker pavement is required.

"Lighter, less expensive and other types of asphalt pavements have proven suitable for airport surfaces servicing planes lighter than bombers. For the latter, only the higher-type asphaltic pavements and methods should be considered even though types of pavement, flexible and rigid, are available for surfacing. Asphalt pavements being of the flexible type can withstand great flexure and can freely utilize the supporting value of the subgrade to obtain optimun economical paving thickness. Rigid type pavements can flex but little, and therefore, require a certain minimum thickness for any given load irrespective of subgrade support. Asphalt pavement being flexible type can adjust itself to unequal settlements with less distress than one of the rigid types. Asphalt pavements can be readily and rapidly increased in thickness thus permitting a field servicing lighter planes to be converted to a field that can service heavier bombers. The initial low cost of asphalt surfacing is paralleled by long range cost of upkeep."

Bureau Reports on Coal Hydrogenation

Experiments in hydrogenation of coals indicate that the United States can develop enormous amounts of gasoline and oil from its coal reserves, the Bureau of Mines has reported April 10.

The process, if applied to the total coal reserves of the United States, could yield enough oil to supply the nation's needs for almost 3000 years at the present rate of consumption. Coal reserves are estimated at some 3,000,000,000,000 tons—enough to yield 3,800,000,000,000 barrels of oil.

With petroleum reserves limited by nature, the hydrogenation process which has been worked out in the Bureau of Mines' Pittsburgh laboratories gives assurances for the future of the gasoline age. While definitely establishing the process feasible and in certain circumstances advisable, technicians have not estimated the cost of gasoline and oil produced from coal on a perfected quantity production basis.

As a preparedness measure, in anticipation of the day when America's petroleum reserves are exhausted or in serious danger of depletion, the Bureau of Mines is making an intensive investigation of all major types of domestic coals to determine their ability to yield gasoline and other oil products, Dr. R. R. Sayers, director of the bureau, said.

Chemical engineers of the bureau, Sayers said, have just completed studies of various coals from four different regions of the United States, bringing to 13 the total number of coals that have been tested at the bureau. These 13 coals represent typical, American varieties, ranging from high-volatile bituminous down to the lignites.

In a report presented by four Bureau of Mines chemists before the American Society, meeting in St. Louis, April 10, 1941, it was shown that the bituminous coals such as those obtained from the Pittsburgh bed, Pennsylvania, the Black Creek bed, Alabama, and the Lower Sunnyside bed, Utah, can yield an average of two tons of oil for each three tons of coal mined; and that the plentiful lignite coals, such as those found in North Dakota, can yield about a ton of oil for each three tons mined.

The tests were conducted in a continuously operating experimental plant capable of handling about 100 pounds of coal a day.

The crude oil produced from coal is similar to crude petroleum, and yields a relatively high percentage of gasoline and various oils. Some of these oils are of possible industrial significance as sources of phenolic compounds and solvents used in the lacquer and plastic industries. Other applications of these oils will develop as their properties are more thoroughly determined.

Reports from the laboratory show that in the first stage (after the coal has been liquefied and before the products are "cracked" to produce various compounds) the oil products obtained contain about 20 percent gasoline, 70 percent of an oil of medium viscosity and boiling range, and 10 percent of a heavy oil of high viscosity and boiling range. The yields of crude oil range from 67 to 31 tons per 100 tons of coal, or 168 to 78 gallons per ton of coal as mined. This spread in yield is largely due to variation in moisture and oxygen content of the coals.

The ultimate yield of gasoline may be easily estimated, for the conversion of the medium oil into gasoline is readily accomplished by well known methods, and the yields of gasoline are about 100 gallons for each 100 gallons of oil.

The Bureau of Mines plans to continue these studies until it has obtained knowledge that will enable it to determine the yields and quality of liquid products obtainable from various American coals so that when the commercial need arises American industry will be in a position to select the most suitable coals and make rapid progress in establishing this new industry. Although the United States has large deposits of both petroleum and coal at present, there is little doubt that petroleum reserves are much smaller than coal reserves and that at some future date the "hydrogenation of coal" to produce gasoline and bulk organic chemicals will be essential. When production costs permit, coal hydrogenation probably will serve as an auxiliary source of gasoline, diesel oil, tar acids and solvents. It is not necessary to envision the exhaustion of petroleum before coal hydrogenation can become economically feasible.

In explaining the experiments carried on by the Bureau, Director Sayers said, the essential differences between bituminous coal and petroleum are the ratio of the number of carbon atoms to hydrogen atoms (which is about 1.2 for bituminous coal and 0.6 for petroleum); the much lower oxygen, nitrogen and sulphur content of petroleum; and the lower molecular weight of the petroleum constituents. Therefore, to produce a petroleum-like material, it is necessary approximately to double the hydrogen atoms in bituminous coal, to remove virtually all of the oxygen, nitrogen and sulphur, and to disassociate or "crack" the coal molecules until their molecular weight about equals that of the petroleum molecules. By adding hydrogen to the coal under high pressures (3000 to 15,000 pounds per square inch) and at high temperatures (750° to 950° F.) oil

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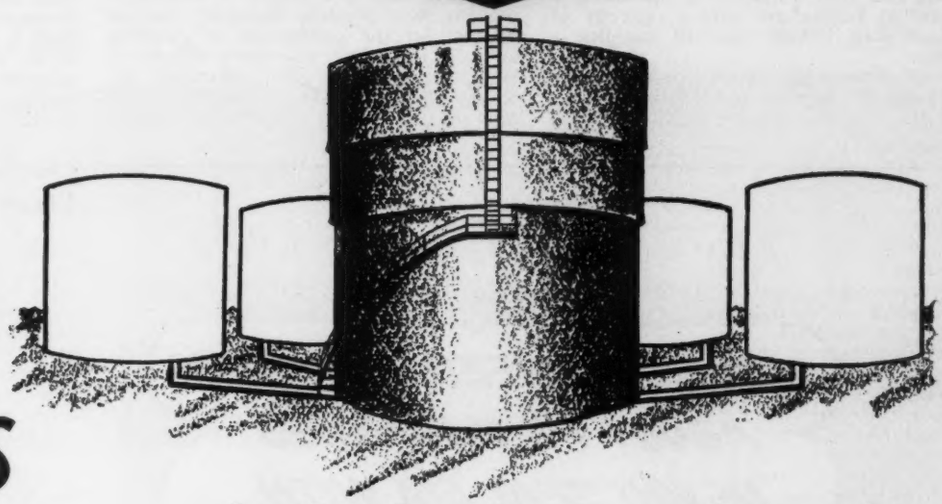

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similar to crude petroleum is obtained. Such a procedure, termed the liquefaction of coal by hydrogenation, has been utilized in Europe where petroleum is not as easy to obtain as in our own country, especially in war times. Experiments have been carried on in Europe since 1913, and according to the latest information available several large coal-hydrogenation plants are now in operation abroad. It is estimated that Germany has a capacity for producing several million tons of gasoline a year from coal and that England is operating a plant at Billingham with a capacity of more than 150,000 tons of gasoline a year.

All of these plants are operating with the aid of government subsidies because of the urgent need for gasoline which these countries are unable to supply from domestic sources. Aside from gasoline and oil fuel it is now known that large quantities of tar acids useful in making the phenolic type of plastics and of aromatic solvents useful in the paint, varnish, and explosives industries as well as a variety of organic intermediates are being produced from the products of coal hydrogenation in these countries.

The coal hydrogenation studies carried on by the Bureau of Mines have value not only as a means of determining the best possible domestic sources of coal for the production of gasoline and oil fuels but also as a means of supplying certain organic chemicals. Although lignites yield a relatively small amount of oil when submitted to hydrogenation, such coals are plentiful in the United States and easily mined. For example, some lignite coal beds lying close to the earth's surface are from 30 to 90 feet thick.

A description of the method employed by the Bureau of Mines in hydrogenating American coals and results of its early studies, together with descriptions of the plant, drawings, illustrations, charts, tables, diagrams and photographs are contained in a publication just issued by the Bureau. This publication, entitled Technical Paper 622, Hydrogenation and Liquefaction of Coal Part I, by H. H. Storch, L. L. Hirst, C. H. Fisher and G. C. Sprunk, is obtainable for 20 cents from the Superintendent of Documents, Washington D. C.

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Chatfield to Edit Empire Publication

J. C. Chatfield has been appointed editor of "The Empire," publication of Cities Service Oil Company, Bartlesville. He succeeds Don A. McNeal, who resigned to enter military service. Chatfield, who formerly was on the editorial staff of National Petroleum News, Cleveland, was with Indian Territory Illuminating Oil Company until its merger with the parent Cities Service Oil Company.

G. L. Brennan Joins Warren Sales Staff

G. L. Brennan was named manager of the liquefied petroleum gas division of Warren Petroleum Corporation, Tulsa, December 1. Previously he had been with Phillips Petroleum Company for 13 years and was assistant manager of its special products department until he accepted the position with the Warren organization.

The growth in sales of liquefied petroleum gas products is shown by the fact its sales by Warren Petroleum Corporation in 1935 totaled only 55,000 gallons whereas in 1940 the sales were more than 47,000,000 gallons. And this year, sales by the company have shown

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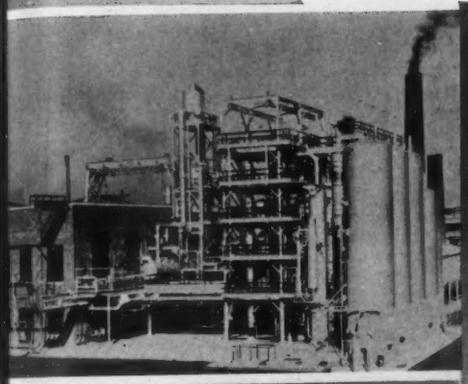

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a very substantial increase over 1940. Much of this business has been developed during the past two or three years.

Born at Devils Lake, North Dakota, in 1896, Brennan graduated from the University of North Dakota in 1919 with a degree of bachelor of science in mining engineering. He then became associated with Harbison Walker Refractories, Inc., in that company's plants in Pittsburgh and Chicago. Later he was connected with Goodman Coal Company in Chicago. He went with Phillips Petroleum Company in February, 1929, his first work being the making of a survey of liquefied petroleum gas marketing conditions. He was made sales manager of the liquefied petroleum gas division of Phillips Petroleum Company, which supplied public utilities, and later became manager of wholesale sales to industrial and utility companies located in the Detroit area.

When Phillips Petroleum Company organized its special products department in July, 1940, Brennan was made assistant manager with headquarters in Bartlesville, the position he has held since.

In addition to Brennan, the staff in the liquefied petroleum gas division of Warren Petroleum Corporation consists of Fred J. LaFortune, P. J. Hoagland, Allen S. James and Kenneth T. White.

Oil Drum Price Limit Fixed

Price ceilings on used drums within the petroleum industry were set by Leon Henderson, price administrator, effective December 1. The top price on reconditioned drums is $2.25 each with allowances for additional quotations for longer shipping distances.

The action was necessitated, Henderson explained, by an "inflationary spiral" which has carried the price of used drums from $1.75 in eastern markets 10 months ago to $3.50 and $4.50, as compared with a price of $2.72 for new 55-gallon containers.

"In the case of certain cheaper grades of petroleum products, the cost of the container has become greater than the value of the product is contains," he commented.

The $2.25 price will be the maximum for reconditioned 50- to 55-gallon drums, delivered within 50 miles of the reconditioning plant. For each 75 miles or fraction thereof in excess of this radius, there may be added all actual transportation charges or 10 cents a barrel, whichever is less. A further 50 cents may be added to these charges in California, Washington and Oregon, recognizing the premiums that have prevailed traditionally on the West Coast.

A top of $1.60 delivered is set for drums in a "raw" or uncleaned or unreconditioned state ($2 on the West Coast) and a maximum of $1.25 ($1.65 on the Pacific Coast) is set for drums purchased directly from the person who empties them. A schedule of prices is set on other than 50- to 55-gallon sizes, not to exceed 80 percent of the base price of new containers delivered in carload lots.

Every person buying or selling used drums will be required to keep detailed records for inspection and to submit such reports as may be required by the Office of Price Administration.

Digest of Foreign Literature

By HEINZ HEINEMANN

Catalysis

Catalytic cracking and catalytic hydrogenation prevail in the recent publications in the field of hydrocarbon catalysis. "Cracking" is the subject of French Patent 858029 (issued to I. G. Farbenindustrie). Hydrocarbon oils, particularly naphthas and gas-oils are cracked in two steps, both in the vapor phase and at the same or increasing temperatures, but with dropping pressure (lower in step 2 than in step 1). The catalysts used are solidly constructed in the catalyst chamber. Catalysts are not necessary in the first step and the chamber may be filled with Raschig rings alone, however, weak cracking catalysts like bleaching earths may be used. In the second step, highly effective catalysts are applied, such as aluminumsilicates or bleaching earths, which have been activated with acids (particularly HF), or clay or active coal. These can be activated with oxides of chromium, molybdenum, tungsten, magnesium, zinc. High yields of high-octane gasolines which are very lead susceptible are obtained.

The same subject is treated in another patent to I. G. Farbenindustrie (English Patent 521687) on "Cracking." Hydrocarbons are cracked in the vapor phase on solidly constructed catalysts. In the course of the cracking operation the pressure is increased by at least 5, better 10 or more atmospheres and the temperature is increased by at least 10° C. The gasoline obtained needs no further refining, is of high octane number and very lead susceptible.

A new "Catalyst for Hydrogenation and Cracking" is claimed by International Hydrogenation Patents Company in French Patent 857173. The dry ammonium-sulfo salts of metals of the sixth group, particularly of molybdenum and tungsten are mixed with salts of metals of the eighth group (like iron, nickel or cobalt) with CO_3 or organic acids (like oxalic or acetic acids) in the atomar ratio of 1:2. The mixture is heated to 300 to 500° C. (preferably 375-475° C.) in the presence of hydrogen, hydrogensulfide, carbondioxide or the like, until no further ammonia development takes place.

Raney catalysts are playing an ever-increasing roll for hydrogenations and also for other catalytic reactions. In an article "Hydrogenations with Raney Catalysts" (Angewandte Chemie, 54, 19/20 and 54, 21/22, pg. 229 and 252) R. Schroeter gives a thorough study of publications on the subject and relates his own experiences. Methods for the preparation of Raney nickel are given. Aluminum is molten and heated further to 900 to 1200° C. Then nickel in an amount of 30 to 60 percent of the mixture is added. An alloy forms under considerable heat development. The eutecticum and to a certain extent the qualities of the finished catalyst depend on the aluminum-nickel ratio. The alloy is broken into small pieces and if possible pulverized and then slowly given into an ice-cooled 25 percent sodiumhydroxide solution, which dissolves the aluminum. After there is no further hydrogen development, the mixture is heated to 90 to 120° C. until the reaction is finished. One lets settle and decants the caustic, repeating the treatment with alkali twice. The remaining metal is then washed with water to neutral reaction and finally kept under alcohol. The metal ignites in the air.

Similar methods of preparation are given for copper, cobalt and iron. The Raney metals contain small amounts of the other metal of the alloy used for their preparation and also keep some hydrogen bound.

Raney nickel is a catalyst for hydrogenations at low temperatures and pressures. It can in many cases replace platinum and palladium. Ethylene can be hydrogenated at much lower temperature and pressure than with Sabatier nickel. Acetylene compound can be hydrogenated at room temperature. The easy hydrogenation of aromatics is of importance. A great number of details concerning the qualities of Raney metals for the hydrogenation of certain compounds are given in the paper.

Raney nickel may also act as an oxygenation catalyst. It decomposes water, whereby it is oxidized to nickelhydroxide. If there is an easily oxydable substance in watery solution, the Raney nickel remains unchanged and acts as an oxygenation catalyst. Stanno salts are oxydized to stanni salts. The catalyst may also be used for dehydrogenations, for instance of isopropylalcohol at its boiling point.

German Patent 678486 (I. G. Farbenindustrie) relates to the prevention of side reactions during the hydrogenation of hydrocarbons. When catalytically hydrogenating mineral oils, one can prevent unfavorable changes of the material at the high temperatures, by distilling the charge stock before hydrogenation in the presence of hydrogen or hydrogen-containing gases under elevated pressure, but in absence of the catalysts. The pressure of the introduced gases should be much higher than the pressure which prevails during the distillation in the reaction vessel. It is particularly effective, if the introduced gases contain liquids like water, alcohol, benzol or the like in the form of fogs which will suddenly evaporate when entering the reaction vessel which is under lower pressure.

A general procedure for the "Execution of Catalytic Gas Reactions" is claimed by I. G. Farbenindustrie in its English Patent 518944. Such gas reactions, particularly the cracking of hydrocarbon oils are executed in a vertical tube, through which the catalyst is passed continuously or periodically. The upper part of the tube serves as the reaction zone, through which the catalyst and the oil vapors are passed in the same direction, while the lower part of the tube is used for the regeneration of the catalyst. Here it is advisable to pass the air for the regeneration countercurrently to the catalyst stream. To avoid a mixing of oil vapors with air from the regeneration process, an inert gas like nitrogen is introduced in the middle of the reaction tube. If the re-

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generation requires more time than the cracking, the lower part of the tube will have a larger diameter than the upper part. The regenerated catalysts are removed at the bottom of the reaction tube and introduced again at the top.

The polymerization of olefines is treated in English patents 518749 and 521891, issued to R. F. Ruthruff, "Polymerization of Olefines." Copperpyrophosphate is proposed as a catalyst for the conversion of gaseous olefines to liquid hydrocarbons, boiling within the range of motor gasoline. The catalyst can also be used in mixture with other pyrophosphates like cadmiumpyrophosphate. The reaction can be carried out at pressures of more than 10 atmospheres. It is advisable to increase the temperature during the course of the reaction above the optimum temperature. For example, heat to 500° F. and then cool to 325-350° F. The copperpyrophosphate is prepared by reacting an aqueous solution of a coppersalt like $CuSO_4$ or copperacetate with a water soluble pyrophosphate like sodiumpyrophosphate. The two salts should be reacted with each other in the theoretical ratio or so that there is a surplus of pyrophosphate. A reducing metal like copper, zinc, with copper activated aluminum or mercury can be added.

Activators for hydrogenation catalysts are described in French Patent 855380, "Pressure Hydrogenation of Coal, Tar and Mineral Oil" (International Hydrogenation Patents Company). The catalysts used are solidly constructed in the reaction chamber and can be activated by hydrogensulfide or hdroygensulfide-generating materials under reaction conditions. The activator such as hydrogensulfide, sulfur, carbondisulfide, ammoniumsulfide or organic sulfides is added from time to time to the charge or to the hydrogen and is added only in such quantities that the desired activation is just effected. During the main reaction period, however, no or only so little of the activator is added that the recuperated hydrogen gas contains no more than .5 Vol. percent, usually less than .3 percent and preferably less than .1 percent of hydrogensulfide.

Lubricating Oils

The importance of making lubricating oils stand up under high pressures is again stressed in a paper by E. A. Evans and J. S. Elliot, "Extreme Pressure Addition Agents" (Journal of the Institute of Petroleum 27,211,65). A classification of the compounds known as suitable for this purpose is given and is augmented by a list of such compounds, tested in own experimental work, by means of the Almen apparatus for measuring the film-rupture strength. The list comprises the use of organic compounds of most different nature, such as hydrocarbons, esters, ketones, sulphur, halogen, nitro, nitrochlorine or phophorus compounds and mixtures of such compounds. The authors declare film strength and film strengthening to be a "new phase of lubrication with a great future."

"Extraction of Hydrocarbon Oils" is the title of French Patent 857169 (N. V. de Bataafsche Petroleum Maatschappij). Mineral oils are extracted with organic selective solvents which contain nitrogen, oxygen, phophorus or sulfur and which have unsaturated partial valances. Such solvents are the lower aliphatic alcohols, aldehydes, ketones, acids, ethers (up to 10 C-atoms), iso and heterocyclic compounds like phenol, fur-

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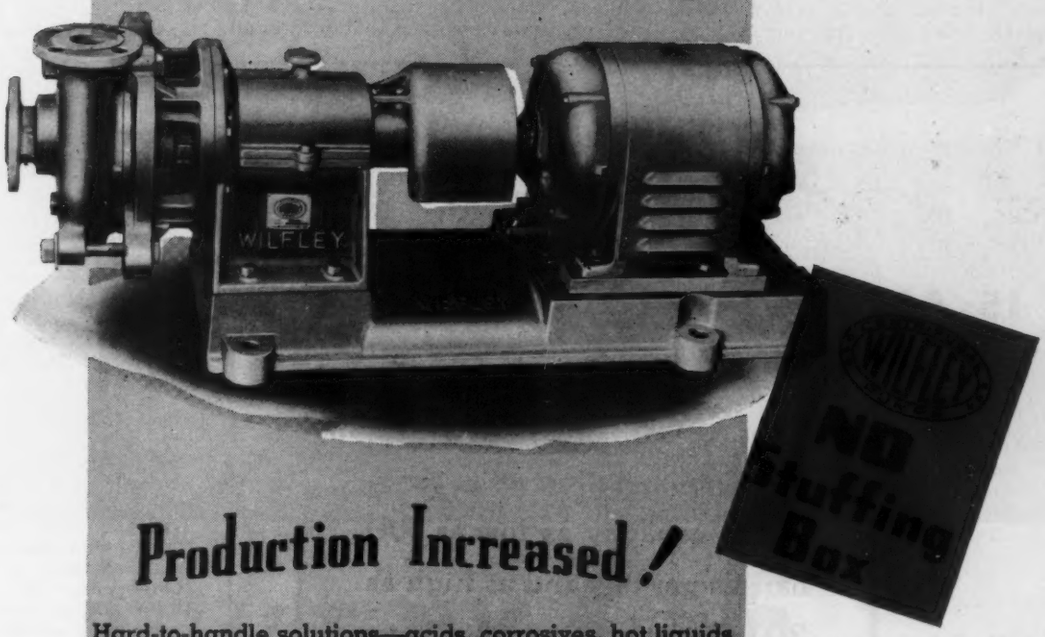

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furol, nitromethane, nitro-benzene, nitrotoluene. The solvents have to be applied together with additives which change the selectivity of the solvents, such as inorganic salts, particularly halides or even free acids like HCl or $H_3Fe(CN)_6$. The additives must be soluble in the solvent and should not change in nature during the extraction. Iso-amyl and isobutylalcohol together with HCl are among others used for the extraction of viscous and light lubricating oils, gas oils or gasoline. The lubricating oils are completely separated while light oils remain in solution.

Desulfurization and Corrosion Prevention

"Refining of Gasolines" is treated in French Patent 856841 (Hydriewerk Scholven A.G.). The gasoline is separated into a lower boiling (up to 135°) and a higher boiling fraction. Approximately .2 percent of sulphur are dissolved in the lower boiling fraction and it is then washed with 10 percent NaOH and distilled, whereby the sulphur remains as residue, finally reunited with the higher boiling fraction, which had been subjected to a hydrogenation.

Desulfurization is of constant interest to the industry and this interest is constantly expressed by new discoveries and publications. "Desulfurization of Sulphur containing Gasolines with Aluminumchloride" is a paper by the Russian authors A. Ja. Szemenova and D. L. Goldstein. They describe experiments to desulfurize sulphur-bearing gasoline from different sources with aluminumchloride at low temperatures (20 to 40° C.). Good results are obtained in all cases. The sulphur content is reduced by more than 90 percent, for instance from .48 percent to .039 percent. When stirring the mixtures more thoroughly, even lower S contents may be attained. The aluminumchloride treatment should be preceded by an alkali treatment. In explanation of the reaction the authors say that the sulphur compounds in the gasoline form liquid complex compounds with the aluminumchloride at low temperatures, which in turn have a refining effect of their own. Utilizing this fact, .35 to .40 percent of aluminumchloride are sufficient to give a good effect.

Desulfurization is also the subject of French Patent 828597, issued to I. G. Farbenindustrie. Acids and sulphur compounds like H_2S, H_2CO_3, CS_2, mercaptans, and the like are extracted from hydrocarbon mixtures by means of salt solutions, using salts from weak organic acids with strong organic or inorganic bases. Salts of the aminoacids are particularly suitable. Concentrated solutions, containing 20-50 percent of the salts are used. When washing light hydrocarbons, it is recommended to work under elevated pressure in order to prevent emulsification on account of the gas formation taking place. Acids, like hydrogensulfide and carbonic acid are treated with relatively weak basic salts. For compounds like CS_2 and H_2SO_3 compounds have to be selected which do not contain free H-atoms bound to an N-atom.

Corrosion prevention by "Neutralization of Acidified Oils" is treated in French Patent 857884 (N. V. de Bataafsche P.M.). Mineral oil distillates, particularly cracked gasolines or polymerization products which were obtained in a process using sulfuric acid, are neutralized with aqueous alkali while adding small amounts of oil soluble nitrogen compounds, like ammonia, organic amines or oxyamines. This causes the immediate neutralization of the acids which are freed by decomposition of sulfuric acid-esters. The neutral products then react with the aqueous alkali solution. Corrosion by free acids is thus avoided and no surplus of alkali is required.

ASTM Petroleum Standards Available

The American Society for Testing Materials, 260 South Broad Street, Philadelphia, has released its publication of standards on petroleum products and lubricants, which can be had from headquarters. Details of the publication have been forwarded from the society as follows:

"The sixteenth edition of this publication issued annually by the American Society for Testing Materials since 1926 provides in compact form all of the test methods, specifications, definitions and charts developed through the work of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants. The 1941 book includes 69 methods of testing, 11 specifications, and 2 lists of definitions of terms. In addition, four proposed new methods, approved for publication as information and for comment, are given covering tests for neutralization number (by electrometric titration, and for crankcase oils), potential gum in aviation gasoline, and conversion of kinematic to Saybolt Furol viscosity. A revised Diesel fuel oil classification is also included.

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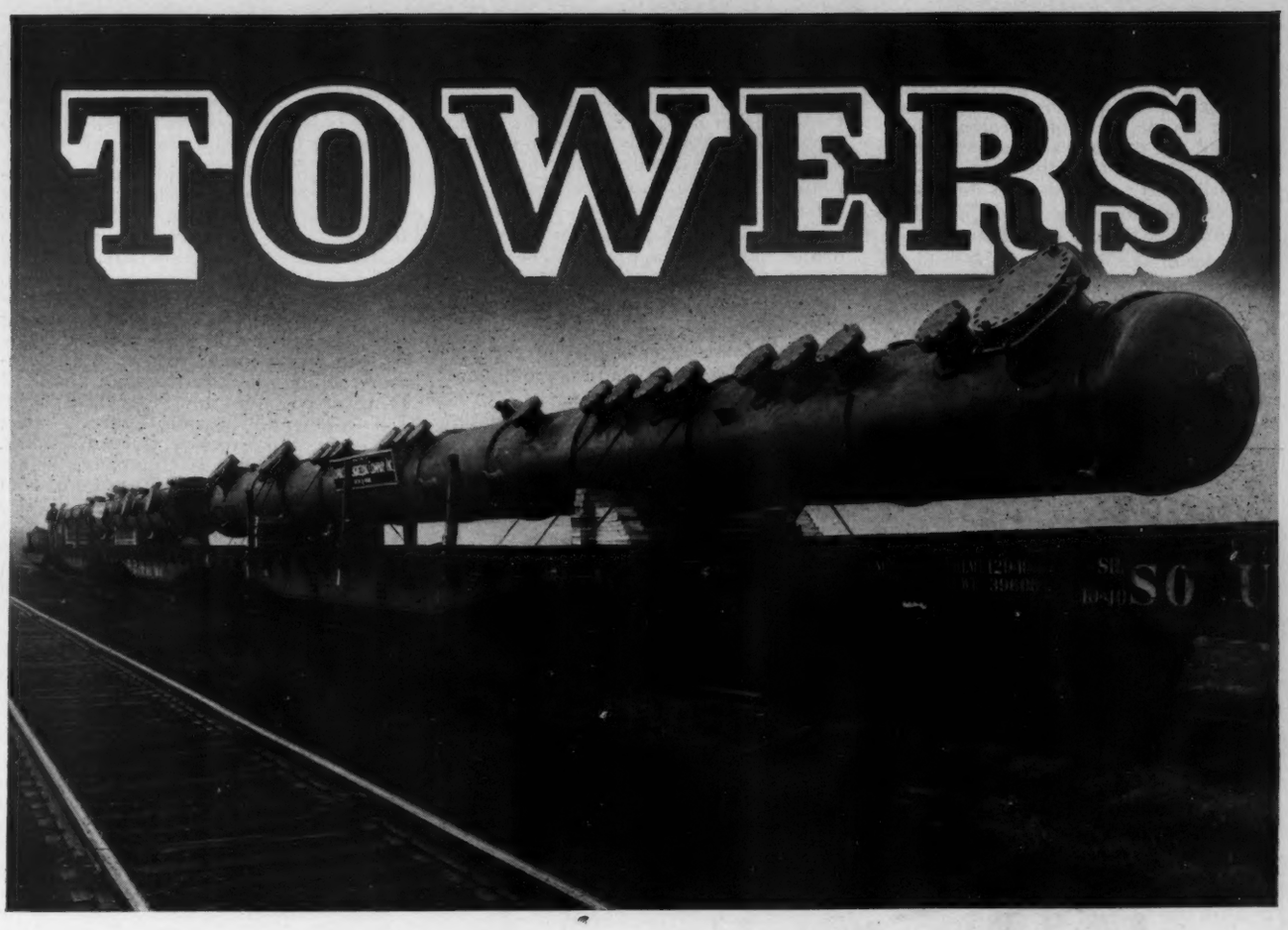

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ume provide specifications for aviation gasoline and tests for knock characteristics of aviation fuels, standardized method of determining the ignition quality of Diesel fuels, and procedures for testing the aniline point of petroleum products and for carbonizable substances in paraffin wax. During the year some 13 standards were revised—full details are given in the annual report of Committee D-2 published in the compilation.

"Copies of this 400-page book in heavy paper binding with two tables of contents, one listing the standards in order of numeric sequence, can be obtained from A.S.T.M. Headquarters, 260 South Broad Street, Philadelphia, at $2.00 per copy, with a price of $1.50 in effect for 10 or more copies."

▼ PLANT ACTIVITIES ▼

Construction of facilities for the manufacture of 100-octane aviation gasoline have come to dominate the petroleum refining industry. Late in November the office of the Petroleum Coordinator released a list of 18 plants, on which priorities have been approved. There were eight plants under construction at the time. Applications are pending on other plants.

This construction is part of the program of increasing the daily output of 100-octane aviation gasoline from 40,000 barrels at present to 126,000 barrels in 1943. Indications are that capacity will be 44,000 barrels by January 1.

Plants on which priorities were assured in November include: Shamrock Oil & Gas Company, Amarillo, isobutane; The Atlantic Refining Company, Philadelphia, 100-octane; Standard Oil Company of California, Richmond, special cracking unit; Union Oil Company, Los Angeles, special cracking unit; Standard Oil Company of Ohio, Toledo, isopentane; Union Oil Company, Wilmington, isopentane; Shell Oil Company, Wilmington, isopentane; Shell Oil Company, Houston, hydrocodimer; LaGloria Corporation, Corpus Christi, isobutane; Shell Oil Company, Wood River, isopentane; Phillips Petroleum Company, Borger, 100-octane; Gulf Refining Company, base stock; Shell Development Company, Emoryville, pilot plant; Cities Service Oil Company, East Chicago, 100-octane; Warren Petroleum Corporation, Tulsa, isobutane; Standard Oil Company of Louisiana, Baton Rouge, catalytic cracking; Gulf Oil Corporation, Port Arthur, 100-octane; Sinclair Refining Company, Houston, alkylation.

Two additional lubricant plants, to be built especially for making aviation oils, have been granted priority ratings, Sinclair Refining Company, Houston, and Sun Oil Company, Marcus Hook. A pilot plant for Shell Oil Company at Houston also was granted priority ratings.

Plants already under construction include: Shell Oil Company, Norco, Louisiana; Standard Oil Company of Ohio, Toledo; Standard Oil Company of Indiana, Whiting; The Texas Company, Port Arthur; Gulf Refining Company, Port Arthur; Standard Oil Company of California, El Segundo; Tide Water Associated Oil Company, Avon; Humble Oil & Refining Company, Baytown.

Other plant construction announced during November included:

Fluid Catalyst: Standard Oil Company of New Jersey let contract to Foster Wheeler Corporation for construction of a cracking unit, which will use the fluid catalyst process, announced earlier in the year. This plant will be built at the Bayway, New Jersey, works and immediate construction is in prospect. It will have daily capacity of 5500 barrels of high-octane motor gasoline and sufficient by-product gases for the production of 5000 barrels daily of aviation alkylate.

Two other plants of this type are under construction, one at Baton Rouge by Standard Oil Company of Louisiana and one at Baytown by Humble Oil & Refining Company.

Recycling Plant: A large recycling plant is to be built in the Katy field, near Houston, by Humble Oil & Refining Company and associates. Stearns-Roger Manufacturing Company has been given the contract for this plant, which will have capacity for handling 200,000,000 cubic feet of distillate laden gases daily. Two other plants of 150,000,000 cubic feet daily are operating. Cost will be around $3,000,000. Work will start within a few weeks. Output

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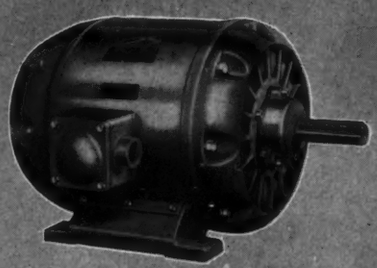

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of finished products will be around 5000 barrels daily.

In addition to Humble Oil & Refining Company, which will operate the plant, others interested in the unitized project are: The Atlantic Refining Company, Darby Petroleum Corporation, Lion Oil Refining Company, Magnolia Petroleum Company, Sinclair Prairie Oil Company, Stanolind Oil & Gas Company, Sun Oil Company, Tide Water Associated Oil Company, Amerada Petroleum Corporation, Ohio Oil Company and Union Producing Company.

Lube Plant: Advanced priority ratings have been granted Standard Oil Company of California for its aviation lubricants plant. Preliminary plans were announced previous to priority assurance. It is not likely that materials will be available until after January 1, 1942. The plant is due to cost $5,000,000.

Gasoline Plant: Phillips Petroleum Company will build a 25,000-gallon daily output natural gasoline plant in the Vacuum field, Lea County, New Mexico. The company has five other plants in the county, all absorption.

Acid Plant: Ethyl Gasoline Corporation will make addition to plant facilities at Baton Rouge for the production of hydrochloric acid, which will be substituted for chlorine in the manufacture of tetraethyl lead. The project is to cost $2,500,000. The chlorine plant, operated at Baton Rouge by the chemical division of E. I. DuPont de Nemours & Company is to have additional liquefication equipment installed and its output will be diverted to uses other than tetraethyl lead manufacture.

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Liquid: Colorless, semi-opaque viscous solution.
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Flake: Thin, white, opaque deliquescent flakes, practically free from dust.

ANHYDROUS AMMONIA NH_3
Colorless gas with extremely pungent odor at normal temperatures and pressure. Liquefies at −33.4°C. at atmospheric pressure. Specific gravity at 0°C. and one atmosphere 0.596; boiling point −33.4°C.

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In three forms. Liquid: Colorless to dark, somewhat opaque, viscous solution.
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Liquefies at −34.6°C. at atmospheric pressure. Not over 1.4 lbs. moisture per ton. Total residue not over 15 grams per 100 lbs.

Valve Pressure Regulations Fixed

New Simplified Practice Recommendations listing simplified schedules of pressure ratings recommended for brass or bronze and iron-body valves have been approved for promulgation, according to an announcement of the Division of Simplified Practice, National Bureau of Standards. The recommendations will be identified as Simplified Practice Recommendation R183-42, Brass or Bronze Valves (Pressure ratings) and Simplified Practice Recommendation R184-42, Iron Body Valves (Pressure ratings). They apply to steam rated gate, globe, angle and check valves, and will be effective for new production from January 1, 1942.

Surveys of the industry showed that 97 percent of all bronze or brass valves shipped in 1939 fell into one of the 5 pressure classifications, whereas the other 3 percent of shipments were distributed over 6 other pressure classes: Likewise 95 percent of all iron-body valves shipped fell in 3 pressure classifications, while 9 other pressure ratings enjoyed between them only 5 percent of demand. The simplified schedules recommend the continued manufacture as regular stock of valves in only those pressure ratings enjoying substantial consumer demand. Bronze or brass valves size ⅛ to 3 inches inclusive, are recommended to be stocked only in 100-, 125-, 150-, 200-, and 300-pound steam working pressure; iron-body valves, size 2 to 12 inches inclusive, in 125- and 250-pound, and size 3-inch and smaller in 150-pound steam working pressure.

The purpose of such simplified practice is succinctly stated by Leon Henderson, then Administrator of the Office of Price Administration and Civilian Supply, at whose suggestion the projects were undertaken, in his letter of June 18, 1941, to the industry:

"As one means of insuring the most efficient utilization of the country's productive facilities, we are endeavoring to bring about a standardization of manufactured articles in certain industries . . . As you may well appreciate, if the emphasis in manufacturing could be placed on certain basic types of valves, producers could make them on a mass production basis with the assurance that they could dispose of their stocks. By the shifting of consumer demand to the standard types, both men and machines would be freed from the production of other types, and, as a result, the output of the industry would be increased."

Until printed issues are available, mimeographed copies of these recommendations may be obtained from the Division of Simplified Practice, National Bureau of Standards, Washington, D. C.

Walter H. Meier Dies After Long Illness

Walter H. Meier, supervisor of the natural gas department of The Atlantic Refining Company, Dallas, died November 15 at his home in Arlington, Texas. He had been ill for several months.

He joined the concern in 1920 after serving in World War I, as chief construction engineer. Meier was active over a period of 10 years in the affairs of the American Petroleum Institute and much of his activity was concerned with vocational training.

SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Heats of Combustion and of Formation of the Nine Isomeric Heptanes in Liquid State, G. F. DAVIES AND E. C. GILBERT, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 2730-2.

Reliable values for the heats of combustion and of formation of all of the n-alkanes including n-dodecane, and a few still higher, are known. However, the corresponding data for the branched isomers have until recently been unavailable. Recently obtained data for the hexanes indicated the desirability of having further information with respect to compounds of increasingly complex structure. The investigators, therefore, studied eight branched heptanes made available to them from the Laboratory of the Standard Oil Company of California. The isothermal heats of combustion at 25° were determined for nine isomeric heptanes. From these data the energies of isomerization for the heptanes in liquid form were calculated. The heats of formation at 25° were calculated, and are presented in tabular form in the article. The properties of the hydrocarbons studied are also recorded.

The Viscosity Function. III. Complete Viscosity Range, E. P. IRANY, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 2611-7.

In an earlier paper the author showed that the viscosity functions of all ideal mixtures follow one common law which, deduced by graphical means, is represented by the ϕ scale of viscosity. The observation that the temperature-viscosity functions of most pure liquids obey the same or a closely related scale-law indicates its fundamental significance. The combined evidence amply supports the conclusion that an ideal law governing the additivity of liquid viscosity is definable and that its expression by the ϕ scale is unique. The task of extending the functional viscosity scales beyond the limited range determined in the first paper of the series, demands rigorous criteria of ideality. Calorimetric, gravimetric or cryoscopic evidence becomes too uncertain in the complex substances that possess high viscosity. However, sensitive criteria of ideality are available by postulating the continuity of those principles and regularities that have been revealed in the lower ranges of the scales. It has been proved that an ideal mixture function and an ideal temperature function can be recognized as continuous and unique throughout the range of practical viscometry, from about 0.1 to 5000 centipoises. These scale functions of viscosity are, however, different; the earlier postulate of their identity has been abandoned and replaced by a quantitatively defined relationship. The pressure scale (π) has been extended tentatively to nearly 10,000 centipoises. The three Viscosity scales (ϕ, θ and π) are derived from experimental data on individual liquids each of which can cover only a limited range of liquid conditions. These sections of the basic viscosity functions have been joined into continuity. It is possible to define a factitious "ideal liquid" capable of passing through all conceivable variations of the liquid state without limitation, in accord with the fundamental law embodied in the three scales. The latter provide the most extensive empirical evidence to test the validity of mathematical formulations of the viscosity functions. The application of the scales to petroleum oils is considered in some detail in the article, both for paraffinic and for naphthenic lubricating oils.

Viscosity of Ethylene and of Carbon Dioxide under Pressure, E. W. COMINGS AND R. S. EGLY, *Ind. & Eng. Chem.* **33** (1941) pp. 1224-9.

A method of predicting the viscosity of pure gases and vapors at elevated pressures was described in a previous article. The data available in the literature were used in developing this method. However, no measurements of gas viscosity at high pressures were available in the range of reduced temperatures from 1.03 to 1.63. Since the effect of pressure on the viscosity varies greatly in this temperature range, viscosity measurements have now been made on ethylene on an appartus of the capillary flow type. The viscosity of ethylene vapor was measured at 40° C. and at pressures from 4.40 to 137.1 atmospheres absolute. The vapor was forced through a glass capillary by the weight of a pellet of mercury and the time of fall of the pellet determined. The viscometer was calibrated, independent of the results on any other gas, but the calibration was checked by measurements on carbon dioxide vapor. The values reported are averages of measurements made with several sizes of pellet. The maximum probable error is 2 percent below and 4 percent above 89 atmospheres. The viscosities of these gases may be used in the design of equipment for high-pressure processes. By supporting the general correlation of the effect of pressure on the viscosity of gases presented earlier they serve as a basis for predicting the viscosity of other gases at high pressures.

Chemical Compositions and Reactions

The Reduction of Multiple Carbon-Carbon Bonds. III. Further Studies on the Preparation of Olefins from Acetylenes, K. N. CAMPBELL AND L. T. EBY, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 2683-5.

The cis forms of 2-hexene and 2-octene have been prepared by catalytic hydrogenation of dialkylacetylenes, and the trans forms by sodium-liquid ammonia reduction. The sodium-liquid ammonia method has been applied to the preparation of 1-alkenes and found to yield pure substances. Two acetylenic carbinols have been converted to the olefinic carbinols by both methods of reduction. The physical constants of the isomeric straight-chain hexenes and octenes were determined, and the relationship between the physical constants and the position of the double bond discussed. A useful tabulation of the properties of the olefins, acetylenes, some

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2 Tacking is done in a sufficient number of places to insure its desired position. No clamps are necessary. Then weld, following and filling in the bevel along the base of the fitting. This assures a junction of full pipe strength.

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4 After the fitting is installed on the main pipe and the button removed, the inside of the joint is in full view for inspection. Interior inspection is impossible with welded pipe-to-pipe intersections, welding tees, saddles, etc. Icicles, scale and excess welding metal are eliminated when WeldOlets or ThredOlets are used. They are removed with the button.

5 The branch pipe is then firmly tacked to the outlet of the WeldOlet which is beveled at an angle of 45°. To complete the junction, it is only necessary to bevel the end of the branch pipe at 45° and weld it into place. When using ThredOlets, the threaded pipe is screwed into position, or if Socket-End WeldOlets are used, the branch pipe is slipped into the fitting and an ordinary weld made around the top of the fitting.

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alkenes, and some of the alcohols, is included in the article.

Effects of High-Voltage Discharge on Thermal Decomposition of Ethane, I. H. PARRILL AND W. G. EVERSOLE, *Ind. & Eng. Chem.* **33** (1941) pp. 1316-7.

The purpose of the investigation was to determine the effect of the ozonizer type of glow discharge on ethane at lower temperatures than those at which ethane shows definite decomposition as the result of thermal action alone. The results of the decomposition by the combined thermal and electrical action are compared with the results obtained by thermal and electrical treatment separately. Ethane is decomposed to ethylene and hydrogen in the glow discharges. Methane production becomes greater at higher temperatures and higher energy input. Decomposition of ethane occurs in the glow discharge, yielding decomposition products corresponding to those obtained by thermal action at 300° C. higher temperature. Decomposition proceeds at temperatures as low as 100° C. These temperatures are considerably lower than the minimum of 485° C. for thermal decomposition of ethane.

The Preparation and Dehydrogenation of Spirodecane and 3-Methylspirodecane, C. S. MARVEL AND L. A. BROOKS, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 2630-2.

Spirodecane and 3-methylspirodecane have been prepared by new procedures. Spirodecane was readily dehydrogenated to naphthalene by platinum or palladium catalysts at 325° C., and 3-methylspirodecane was converted to 2-methylnaphthalene by heating with palladium at 325° C. Neither spirodecane nor its 3-methyl derivative was dehydrogenated by selenium at 300-350° C.

The Influence and Behavior of Thiophene on Aromatization Catalysts, R. W. HUMMER AND H. S. TAYLOR, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 2801-5.

In view of the present interest in the cyclization and aromatization of petroleum hydrocarbons by catalytic means, it was considered important to investigate the influence of sulfur on this process. A study of two typical aromatization catalysts, chromium oxide and molybdenum oxide, was made. These substances were of especial interest since they have been shown to be active in removing sulfur compounds from gasoline and benzene. These oxides admixed with hydrocarbons were found to be highly efficient for the removal of thiophene at 470° C. With chromium oxide the greater part of the sulfur was removed as hydrogen sulfide during the course of passage of vapor, with hydrogen present. With molybdenum oxide, on the other hand, only traces of hydrogen sulfide appear during the run, and bulk of the recovered sulfur comes out in the regenerative oxidation. The sulfur from the thiophene has a profound poisoning effect on the aromatization activity of the chromium catalyst, a drop of about 60% in aromatic yield was observed. The aromatization activity of the molybdenum catalyst is considerably enhanced by the passage of sulfur-containing hydrocarbons. An increase in aromatic yield from 21 to 64% was observed under optimum conditions. Sulfur in excess of the optimum depresses the activity but not to its original value.

Oxidation Studies. II. The Oxidation of Diisobutylene in the Presence of Potassium Hydroxide at Elevated Temperature and Pressure, R. W. BOST AND L. B. LOCKHART, JR., *Jour. Amer. Chem. Soc.* **63** (1941) pp. 2790-2.

Although one of the oldest known reactions of organic compounds is that of oxidation, there has been little investigation of the oxidation of organic compounds by molecular oxygen at elevated temperatures and pressures. The investigation reported was undertaken to furnish some further information of this type. The action of molecular oxygen on diisobutylene in the presence of potassium hydroxide and at a temperature of 100° C. and a pressure of 100 pounds per square inch, was studied. Previous work by the authors has shown that the first product under these conditions is peroxide, which then breaks, forming aldehydes and ketones. The aldehydes may then be further oxidized to the corresponding acids. The diisobutylene used was that used in the production of isooctane, and was obtained from the Standard Oil Development Company. The course of the reaction was followed by noting the drop in pressure in the bomb. Diisobutylene showed an induction period of ninety to one hundred and twenty minutes. The reaction is essentially complete in eight hours. A qualitative and quantitative study was made of the oxidation products. The chief products obtained were acetone, 4,4-dimethyl pentanone-2, carbon dioxide, formic acid, and pivalic acid. The presence of oxygen-containing compounds boiling higher than any of the predicted

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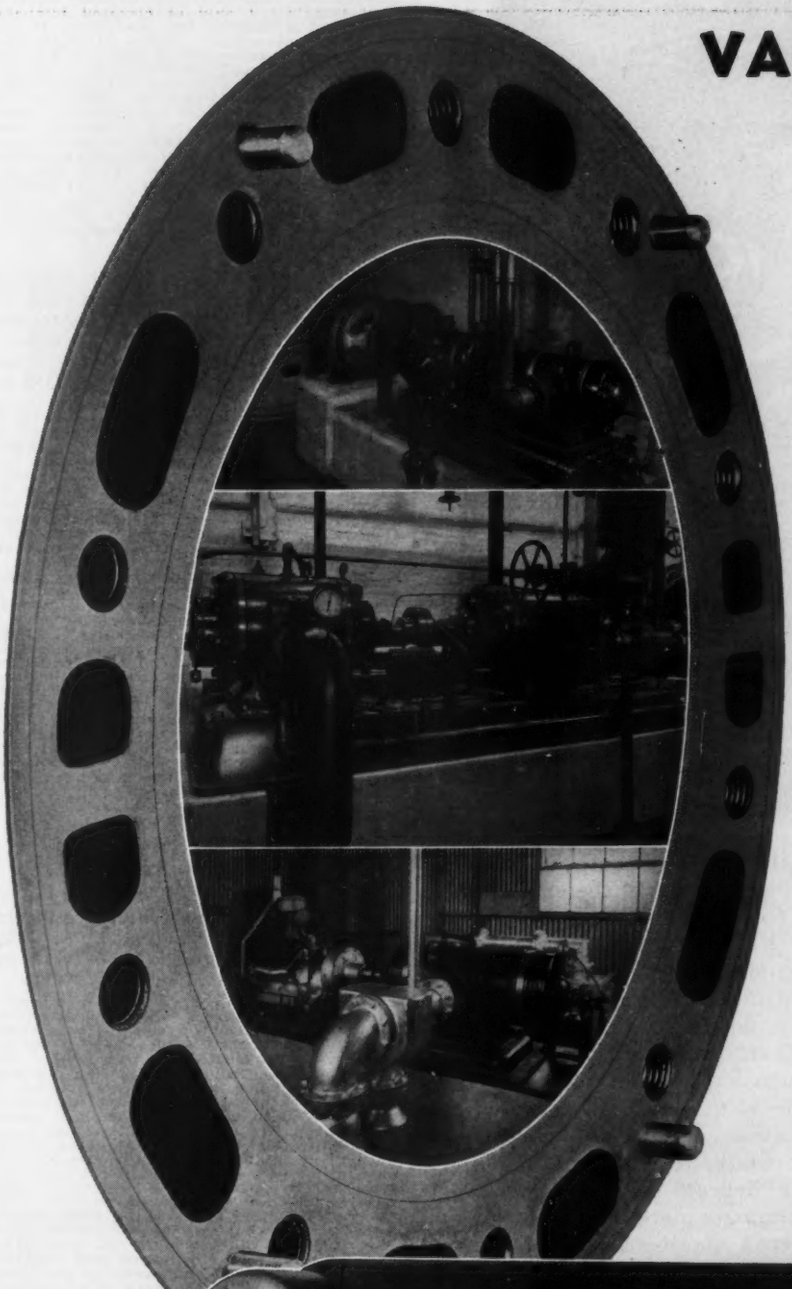

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products was shown. These were not obtained in sufficient quantity and purity for identification.

The Oxygen Effect in the Reaction of Bromine with Neopentane, t-Butylbenzene and Trimethylacetic Acid. M. S. KHARASCH AND M. Z. FINEMAN, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 2776-9.

Preliminary work has shown that tertiary hydrogen atoms are more readily replaced by bromine atoms than are secondary hydrogen atoms. Because of these observations, it was decided to investigate the bromination of compounds containing primary hydrogen atoms. Compounds of this type have hitherto been brominated only at elevated temperatures, and usually in the gas phase. It was decided to investigate the liquid phase bromination of neopentane, t-butylbenzene and trimethylacetic acid. In the absence of oxygen, bromine does not react with neopentane at 80° C. Oxygen had little effect on the reaction of bromine with neopentane at room temperature. At 80° C. it causes a slow reaction. At 50° C. organic peroxides have an effect on the bromination of neopentane similar to that of oxygen at 80° C. The bromination of t-butylbenzene is exclusively nuclear. When treated with bromine at 150° C. trimethylacetic acid yields brominated hydrocarbons and 9% of trimethylacetoxytrimethylacetic acid.

The Peroxide Effect in the Addition of Halogen Acids to Olefins. XXVI. The Addition of Halogen Acids to Trichloromethylethylene, M. S. KHARASCH, E. H. ROSSIN AND E. K. FIELDS, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 2558-60.

The study of the effect of substituents on the direction of addition of halogen acids to ethylene compounds has been a matter of interest for many years. Better understanding of the factors that promote normal and abnormal additions now permits the correlation of the large body of known facts in an unambiguous manner. The data thus far accumulated indicate that in all normal additions where the double bond is not conjugated with the oxygen atom of a carboxyl group the halogen acid adds to produce a secondare or tertiary alkyl halide, rather than a primary halide. In the presence of oxygen and/or peroxides hydrogen bromide adds abnormally and an isomeric bromide is obtained. In the dehydration of 1,1,1-trichloroisopropanol with phosphorus pentoxide, two compounds are formed: (I) trichloromethylethylene and (II) probably 1,1-dichloroallene. Trichloromethylethylene is very unreactive. In the presence of ferric chloride, hydrogen chloride adds slowly to yield 1,1,1,2-tetrachloropropane. Under oxidant conditions hydrogen bromide adds to yield 1,1,1-trichloro-3-bromopropane. Under antioxidant conditions hydrogen bromide does not add to trichloromethylethylene at all.

Manufacture: Processes and Plant

Mean Temperature Difference in Unbalanced-Pass Exchangers, K. A. GARDNER, *Ind. & Eng. Chem.* **33** (1941) pp. 1215-23.

The mean temperature difference in multipass heat exchangers with unequal tube passes can be calculated from the logarithmic mean temperature difference and the correction factors presented in this paper. The derivation of equations for exchangers with single-pass shells and any even number of tube passes is given in detail, and the method for extension to any number of shell passes is described. The equations of previous investigators appear to be special cases of the author's general equations. The results are based on the usual assumptions, and are presented in terms of the customary parameters plus an additional parameter involving the ratio of unbalance of the surfaces and rates in the counterflow and parallel-flow tube passes. A discussion of the advantages and limitations of unbalanced-pass heat exchangers is included and examples are given. An additional use of the data as an approximate correction to mean temperature difference for variation of heat transfer rate in conventional multipass exchangers is suggested.

Heat Transfer Coefficients for the Condensation of Mixed Vapors of Turpentine and Water on a Single Horizontal Tube, E. L. PATTON AND R. A. FEAGAN, JR., *Ind. & Eng. Chem.* **33** (1941) pp. 1237-9.

The purpose of the investigation was to determine the coefficient of heat transfer on the vapor side of a single tube horizontal condenser handling mixed vapors of turpentine and water. The apparatus used is de-

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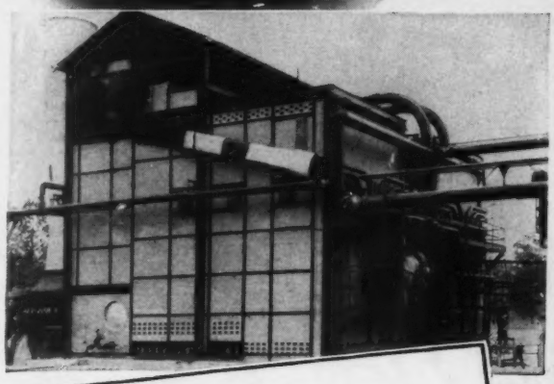
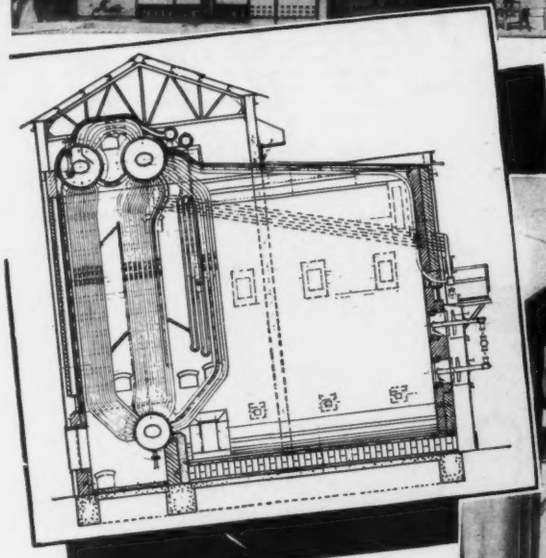


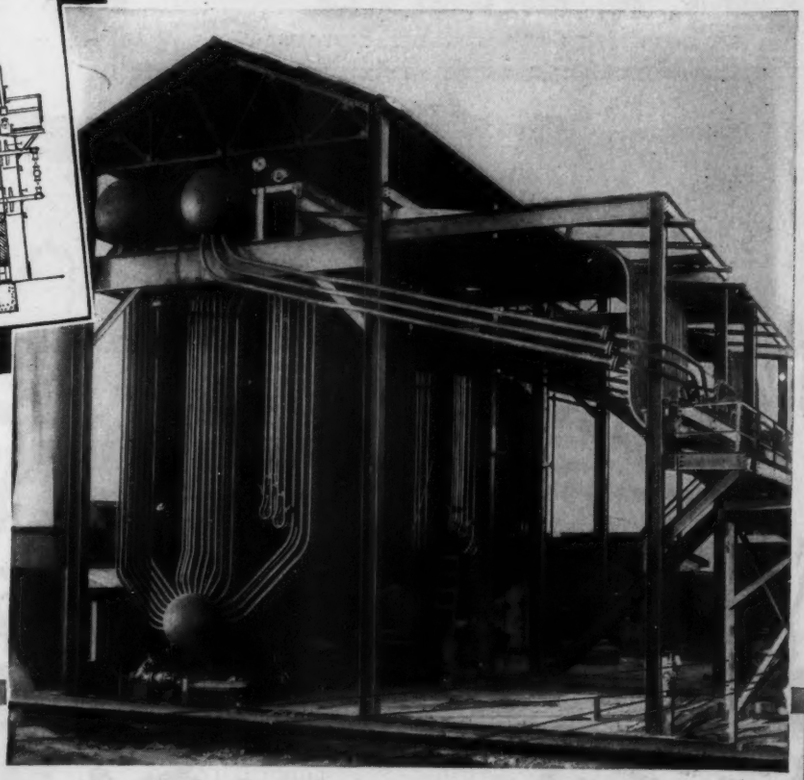
Each of the two units comprising this installation is designed to deliver 95,000 pounds of steam per hour with 165 degrees of superheat, using feed water at 212 degrees F.

Steam and water drums are fusion welded and designed for 400 pounds working pressure.

Furnace walls and floors are air cooled and the furnace roofs water cooled. Burners installed in each furnace are arranged to burn Natural Gas or Refinery Gas Fuel.

These units are provided with a roof only and are operated out in the open like oil stills.





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Comparative Chromium Consumption Using Glucosates as Compared to Chromates

Amt. in form of Glucosate	Amt. as dichromate	Application	Saving
	SODIUM BICHROMATE		
17 pounds	100 pounds	Calcium Brine	83 lbs.
17 pounds	200 pounds	Salt Brine	183 lbs.
34 pounds	500 pounds	Cooling Water	466 lbs.
	CHROMIC ACID		
3 pounds	66 pounds	Calcium Brine	63 lbs.
3 pounds	132 pounds	Salt Brine	129 lbs.
10 pounds	330 pounds	Cooling Water	320 lbs.

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scribed, as well as the experimental procedure. The condensation obtained while condensing mixed vapors of turpentine and water was the film-dropwise type described by Baker and Mueller. The turpentine apparently condensed as a film, and the steam condensed dropwise in and on this film. When pure turpentine was condensed, film-type condensation was obtained. Film coefficients varying from 326 to 514 Btu/sq. ft./hr./1° F. were obtained. The higher the temperature drop through the film, the lower the film coefficient. The data are presented in tabular and graphical form.

The Calculation of Minimum Reflux Ratio in the Distillation of Multicomponent Mixtures, A. P. COLBURN, *Trans. Amer. Inst. Chem. Engrs.* **37** (1941) pp. 805-25.

One of the most important factors to know in the design of distillation apparatus is the minimum reflux ratio, since knowledge of this quantity permits selection of a reasonable operating reflux and may, together with a calculated value of minimum number of plates, permit an operating design from a single graph. For multicomponent mixtures the correct value of minimum reflux ratio has in the past been determined by very laborious calculations. Approximate methods available are valuable but not sufficiently precise. The method proposed by the author involves relatively straight-forward calculation of the compositions in the two pinched-in regions occurring in this case at a number of trial values of reflux ratio, with a simple empirical factor to indicate when these compositions are in proper relation to each other, thereby determining the predicted value of minimum reflux. The empirical factor was determined from 32 new examples as well as from 5 examples from the literature, in each of which the correct value of minimum reflux was established by the laborious trial-stepwise procedure. A testing of the method against these 37 examples shows an average error of less than 1% in predicting the minimum reflux ratio expressed as L/D.

Separation of Hydrocarbons by Azeotropic Distillation, B. J. MAIR, A. R. GLASGOW, JR. AND F. D. ROSSINI, *J. Res. Natl. Bur. Standards* **27** (1941) pp. 39-63 (Res. Paper No. 1402).

The authors present the general theory of azeotropic distillation. Practically all organic compounds with polar molecules give minimum boiling point mixtures with hydrocarbon. The boiling point depression below the boiling point of the pure compound increases in the order aromatic, diolefin, monoolefin, naphthene and paraffin. The composition of the constant boiling mixtures depends largely on the relative boiling points of the hydrocarbon and the azeotrope-forming substance. For the separation of hydrocarbons the compounds must be selected that are readily extracted from the hydrocarbons by water. Examples are given of the separation of close-boiling hydrocarbon solutions into paraffins and naphthenes, and the value of azeotropic distillation as a procedure for separation is discussed. The hydrocarbons that can be separated in a substantially pure condition by distillation alone from petroleum or its products are listed.

Fractionating Performance of a Dephegmating Condenser, R. W. TIMMERMAN AND C. L. NICKOLLS, *Ind. & Eng. Chem.* **33** (1941) pp. 1230-3.

Measurements of the separating efficiency of a dephlegmating condenser were made under different operating conditions. A condenser of engineering laboratory scale was used. Binary mixtures of methanol and water were employed in the tests. A greater separating efficiency was obtained with parallel flow of cooling liquid and condensing vapor (both flowing upward) than with the countercurrent flow with vapor flowing upward. The use of reasonably high vapor velocities gave better fractionation than low velocities. With parallel flow of vapor and liquid, the efficiency increased definitely with increasing reflux ratio. With countercurrent flow the efficiency decreased slightly with increasing reflux ratio. A wide variation in concentration of the entering vapor had but a small effect on the theoretical plate equivalent separation obtained. The data are presented in some detail in tabular and graphical form.

Liquid-Liquid Extraction Data, D. F. OTHMER, R. E. WHITE AND E. TRUEGER, *Ind. & Eng. Chem.* **33** (1941) pp. 1240-8.

Data of a physical-chemical nature form the fundamentals upon which the development of liquid-liquid extraction processes are based. Among these data are the solubility relations, i.e., mutual solubility and distribution coefficients for the components involved. These relationships cannot be predicted, but must be determined experimentally. The usual extraction system involves three liquid components — one pair of immiscible liquids and two pairs of miscible liquids. When the three

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components are present in such quantities that two liquid phases exist, the common miscible liquid distributes itself between the immiscible pair in accordance with the distribution law. The presence of the miscible liquid increases the solubilities of the immiscible pair in each other; in other words, the mutual solubility increases. When two phases exist, they are mutually saturated and a plot of the compositions, on triangular coordinates, of these saturated phases give the so-called mutual solubility curve. Simple and rapid methods for determining accurate data for these relations have been developed through modification of previous methods. Several methods of correlating the distribution data have been investigated in an effort to evaluate their advantages. Distribution and mutual solubility data and representative plots for a number of systems of acetic acid-water-solvent, acetone-water-solvent, and ethyl alcohol-water-solvent are given. These systems are of commercial importance since extraction processes involving them are used industrially and are the bases of many patents. The principles involved in the work can be applied to many different systems. The data are presented in detail in tabular and graphical form.

Solvent Dewaxing of Lubricants, CHEM. & MET. ENGR. EDITORIAL STAFF, *Chem. & Met. Engr.* **48** (1941) p. 106.

The first commercial installation of the solvent dewaxing process was made at the Indian Refining Company at Lawrenceville, Illinois, about 1928. This was the only installation of its kind for about five years. Since 1933 a total capacity of approximately 40,000 barrels per day of lubricating oil charge has been built. A mixture of two solvents is generally employed. One solvent, for example, methylethylketone, in which wax is substantially insoluble, enables the wax to be crystallized at reduced temperatures in a highly filterable form. The other solvent, for example, benzol, is one in which the oily portion of the hydrocarbon mixture is highly soluble at reduced temperatures. Solvent losses are low, averaging about 0.05% by volume of the solvent circulated. Fire and explosion hazards are reduced to a minimum by use of an inert gas system. The process is used to dewax either distillates or residual stocks from a wide variety of crude petroleum. The waxes produced are low in oil content and the dewaxed oils are free of wax haze.

The Costs of Process Equipment and Accessories, H. BLISS, *Trans. Amer. Inst. Chem. Engrs.* **37** (1941) pp. 763-804.

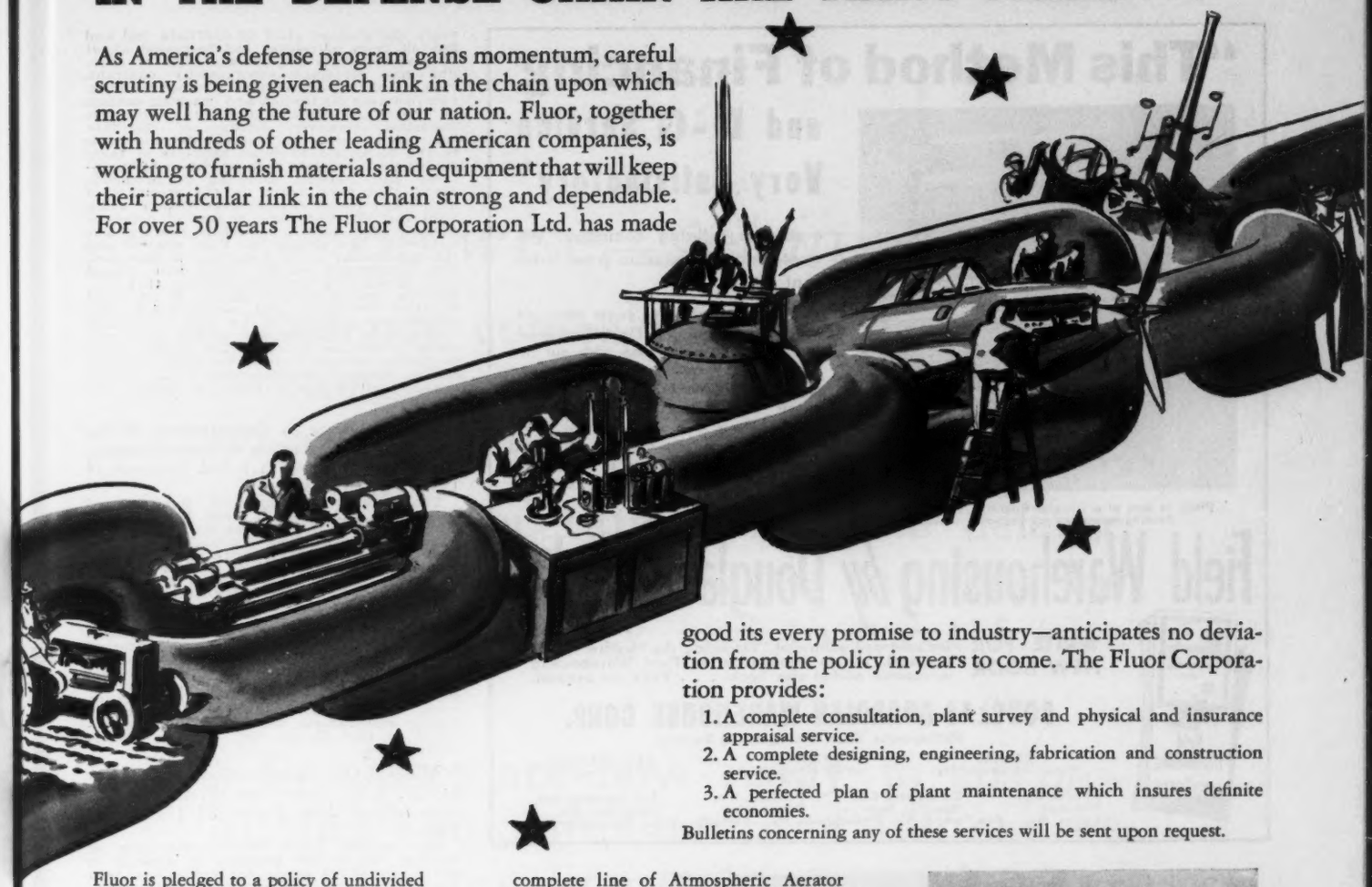
The purpose of the paper is to present information about the original cost of various items of process equipment, and the effects thereon of certain important variables such as construction material, size and type. The costs given were collected in 1940 and 1941, but the author observes that there seems to have been little change in these costs over the past several years. The costs are first given on pipe and tubing, including steel, stainless steel, yellow brass and similar alloys, Everdur and similar alloys, and Monel, nickel and Inconel. This is followed by the cost of fittings. These are influenced by construction material, operating pressure, grinding methods, external finish and size. Factors are given by which the product value should be multiplied to yield the cost of other fittings within the same group but differing from the representative one plotted by one or more of the above variables. Curves are given for the cost of gate valves, together with factors to allow for material, trim material, type of gate, pressure, stem arrangement, jointing method, and size. Charts are then given for heat exchangers, with variations, depending on material, diameter, thickness, and length of tubes, material and size of tube sheet, material, size and thickness of shell, and various special features of design such as floating head, baffles, etc. Pumps are next considered, and curves are given for enclosed impeller centrifugal pumps, non-clogging standard construction centrifugal pumps, and for rotary pumps. Curves are given for gas pumps including single-stage turbo-blowers, multi-stage turbo-blowers, and rotary cast-iron gas pumps. Plot data are then given for thickness, and for filters, including plate and frame, Sweetland, Oliver continuous vacuum filters. Data are given for crystallizers and for dryers, vacuum rotary dryers, and miscellaneous including atmospheric and vacuum pan dryers, vacuum shelf dryers, vacuum rotary dryers, drum dryers, vacuum shelf dryers, vacuum rotary dryers, and miscellaneous types. Charts are given for absorption towers and packings, and finally, for tanks, storage vessels, and linings.

Products: Properties and Utilization

Sludge Formation in Distillate Fuel Oils, R. J. HAWES AND F. M. MILLER, *Ind. & Eng. Chem.* **33** (1941) pp. 1318-20.

The petroleum industry's view of distillate fuel oil as a product of secondary importance is being revised as sales continue to grow with the use of Diesel engines and increased domestic heating by oil. During the last nine

IN THE DEFENSE CHAIN ARE MANY LINKS . . .



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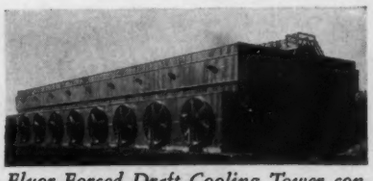
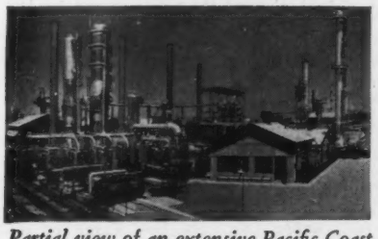
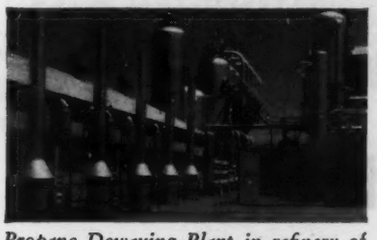


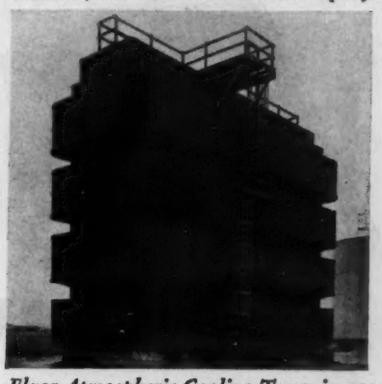
Fluor Forced Draft Cooling Tower constructed for a Mid-Continent oil company.



Partial view of an extensive Pacific Coast Cracking Plant, constructed by Fluor.



Propane Dewaxing Plant in refinery of major oil company, constructed by Fluor.



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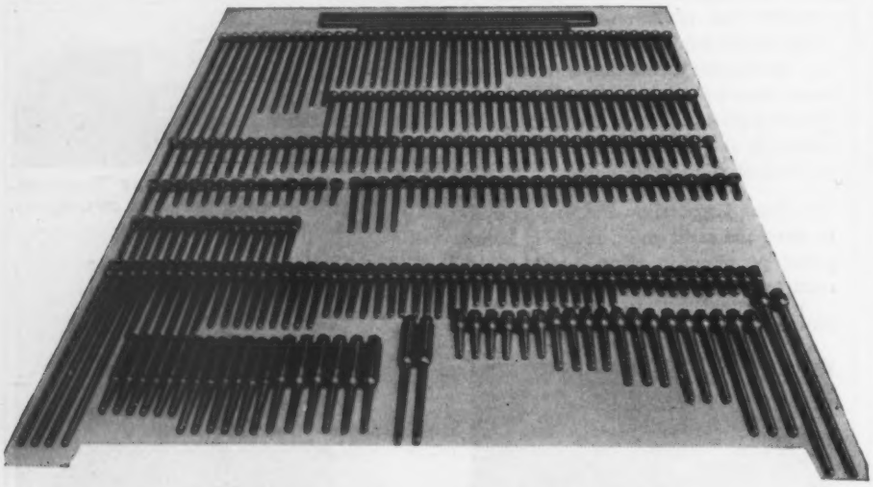

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years the average yield of distillate fuel and gas oil from petroleum has increased about 65 percent, while the average yield of gasoline has remained substantially constant. Furnace oils as conventionally produced from petroleum by distillation and cracking contain no appreciable amounts of sludge or insoluble materials. However, storage of distillate fuel oils to meet the seasonal demand leads to the formation of small amounts of tarry sludge that interfere with operation of equipment and increase servicing requirements. Sludge has been found in the strainers of high-speed Diesel engines even though using light fuel oil. The same is true of domestic fuel oil when used in household heating. The nature of this sludge has been studied and the mechanism of its formation is discussed. The composition of the resins and sludges from consumer's strainers indicate that progressive oxidation-condensation is involved in their formation and accumulation. The mechanism appears to be that essentially oxygen-free hydrocarbons oxidize and condense to resinous material, that further reacts in similar manner to form the more insoluble sludge. Methods for determining the sludge content and sludge stability of furnace oils are described.

The Influence of Temperature on the Lubricating Properties of Some Greases, D. TABOR, *J. Council Sci. Ind. Research* **14** (1941) pp. 147-52.

The friction apparatus of Bowden and Leben has been used to study the effect of temperature on the lubricating properties of some greases. A jerky motion occurs when metal surfaces, lubricated with nonpolar lubricants, slide on one another. In the presence of suitable polar molecules the motion becomes smooth. A lubricant containing polar substances may give smooth sliding at room temperature, but as the temperature increases, jerky motion occurs, and wear is increased because of the desorption of the adsorbed layer. Two commercial greases containing 5% aluminum stearate in a Pennsylvania bright-stock (I), and in a California cylinder-stock (II) gave a similar performance at room temperature, but II was superior at higher temperatures, since smooth sliding persisted to 150° C. At 200° C. both greases broke down.

Mineral Oil Deterioration, J. C. BALSBAUGH, A. G. ASSAF AND W. W. PENDLETON, *Ind. & Eng. Chem.* **33** (1941) pp. 1321-30.

For several years the deterioration of mineral oils in the presence or absence of either copper or paper (or both) has been studied in the laboratories at the Massachusetts Institute of Technology. The paper is a report on the continuation of this work. A study was made of (a) the effect of temperature on the oxidation characteristics of an oil sample with a viscosity of 100 Saybolt seconds at 100° F., (b) the continuous oxidation of a series of related samples having viscosities comparable to those of cable saturants, (c) the effect of a limited amount of oxygen on a water-white aromatic-free oil, and (d) the oxidation and electrical characteristics of cetane and cis-Decalin. The results show that up to 95° C. the mechanism of deterioration was approximately the same. The series of related oils displayed varying electrical and chemical stabilities with varying aromaticity. A limited amount of oxygen produced higher electrical losses than those otained with an unlimited supply; the hydrocarbons exhibited widely divergent chemical and electrical properties. Continuous oxidation of an oil above 95° C. in the presence of paper results in excessive deterioration of the paper.

Colloidal Stability of Asphalts, H. F. WINTERKORN AND G. W. ECKERT, *Ind. & Eng. Chem.* **33** (1941) pp. 1285-9.

Prediction of the service behavior of asphaltic materials by means of simple laboratory tests is important both to the asphalt producer and the road builder. The conventional physical specification tests were valuable as quality indicators as long as only a few well-designed asphalts were on the market. They are failing in their role because of the increasingly varied products that are sold under the collective name of asphaltic bitumen. Failure of bitumen to function properly in a pavement is usually associated with excessive hardening. As long as the hardening is caused only by loss of volatile material it can be easily remedied. On the other hand, the hardening may be caused by a change in the colloidal structure of the bitumen. Therefore methods that indicate or measure the stability of the structure are likely to become increasingly important in the future testing of bitumen. The Oliensis spot test appears to be essentially a method for measuring the colloidal stability of a bitumen. Data are presented on the appearance of spots obtained with a number of different solvents and solvent mixtures as well as results obtained with the standard Oliensis procedure. It is hoped that these data will help in understanding the Oliensis test, and also that some of them may provide a basis for the extension of this test into fields not yet covered.

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Electronic Motor Control

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General Electric Company, Schenectady, New York, has a new electronic control system, Thy-mo-trol, to provide simple stepless control for direct-current motors from alternating current lines wherever a wide speed range is essential.

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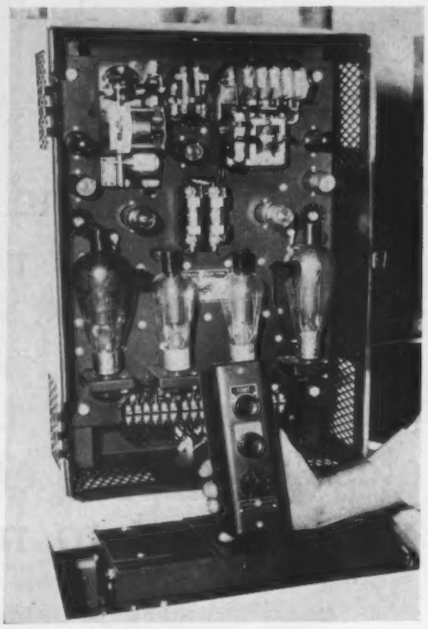
The Thy-mo-trol system provides wide-range speed control without the use of motor-generator sets or gear and pulley arrangements. A single-dial control, mounted in a heavy-duty push-button station, covers the complete speed range of the motor, both above and below basic speed. The motor is automatically accelerated to preset speed quickly and smoothly without excessive current peaks. The same single dial can also be used to change speed to any desired value during operation.

Thy-mo-trol equipment can be provided for reversing service by the addition of a standard magnetic reversing switch. It can also be furnished with dynamic braking.

In operation, the change from alternating to direct current for the motor field and armature circuits is accomplished by two pairs of thyratron tubes. The control compensates for changes in armature-voltage-drop, holding motor speed constant regardless of normal-load and line-voltage variations.

The stepless speed control increases armature voltage up to basic speed and weakens the field at speeds above basic. Acceleration is automatic. Full field is held until basic speed is reached and is also automatically applied during dynamic braking.



Electronic Motor Control

Protective Control Device

THE LINCOLN ELECTRIC COMPANY

The Lincoln Electric Company, 12818 Coit Road, Cleveland, Ohio, has introduced a device for protecting arc-welding machines against heat or excessive current. The protective device consists of two current transformers, the primaries of which are connected in series with the motor leads and the secondaries supplying power to operate two snap-action thermostats, which are mounted directly on the motor lamination. These thermostats are connected to the lamination in such a way that they operate by means of heat conduction as well as by current passing through the thermostat.

The protection provided by this device is explained by the manufacturer as follows:

"If the welder is being operated in a very hot room or an oven and it exceeds the safe operating temperature, thermostats will trip open.

"If the motor is cold and excessive currents which will eventually damage the motor occur for a short period of time, the thermostat will operate before the motor reaches an unsafe temperature.

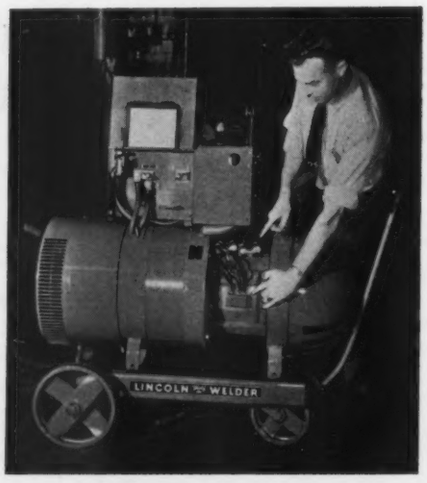
"If the machine is started on single phase lines, the switch may close, but the excessive heating of the thermostat caused by the single phase locked current will open the thermostat and stop the machine.

"If the machine is running and one fuse blows so that the motor is operating single phase, if the load on the machine is sufficient to overheat the motor the thermostats will trip out.

"If the rotor is locked with normal three phase power applied, the thermostats will open the circuit due to the high current.

"If the welder is operated for long periods of time at sustained overloads, both high input current and high motor temperature combine to open the thermostats.

"The thermostats automatically reset when the motor returns to a safe operating temperature or when the current is reduced, and no manual operation is re-



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quired to start the machine, except pushing the start button.

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U-C Level Indicator Sales, 828 North Broadway, Milwaukee, has introduced a new U-C Level Indicator.

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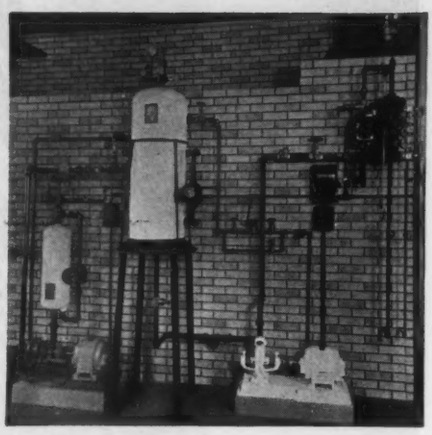


Condensate Return Unit

condensate and make-up water automatically. The systems are substantially designed and include high grade controls, motors and pumps.

Portable Mixer

ALSOP ENGINEERING CORPORATION

Alsop Engineering Corporation, 2 Wright Street, Milldale, Connecticut, has a two-propeller portable mixer which is driven by an electric motor through herringbone gear reduction. The gears operate inside an oil-filled housing that has a metal shaft seal. Thrust in the reduction is taken by roller bearings.

Alsop Portable Mixer

The motor of ball bearing design is available from 1/20- to 50-horsepower. It can be specified as to current requirements, inclosed, explosion proof, drop proof or open type.

The unit can be mounted on the side of a container and by means of a new swivel clamp, the propellers may be positioned to any angle between vertical and horizontal, as well as sideways from the center to provide desired mixing action.

Non-Slip Footwear

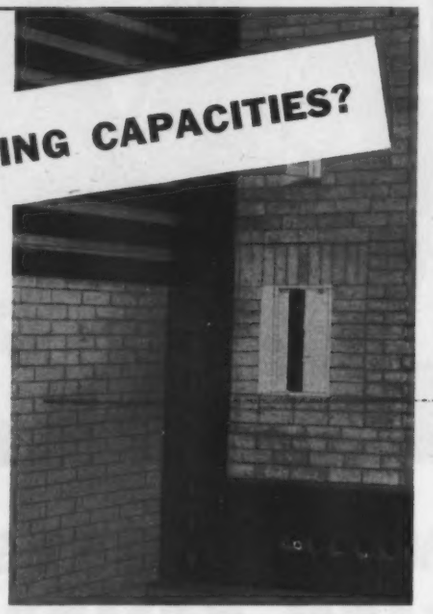
UNITED STATES RUBBER COMPANY

A new type footwear with patented non-slip sole to halt accidents has been designed especially for the oil industry by United States Rubber Company.

On the straight-away this sole is perfectly smooth, and being made of pure white rubber leaves no mark on any

EXPANDING CRACKING CAPACITIES?

CHECK the real economy features of lightweight Armstrong's Insulating Fire Brick



COMBINATION VISEBREAKER *designed and built by the M. W. Kellogg Company. Burner walls: Armstrong's A-26 Brick backed up by 1½" Insulating Block. End and convection walls: Armstrong's A-23 Brick, backed up by 1½" Insulating Block. Roof: A-23 Brick backed up by 1½" Plastic Insulating Cement.*

CRACKING furnaces built with Armstrong's Insulating Fire Brick have advantages you should build into any new units you are planning. You get both construction economies and operating economies with these brick which meet high standards for strength, thermal conductivity, refractoriness, and spalling resistance. Their advantages include:

LIGHTER CONSTRUCTION: The high insulating efficiency of Armstrong's Insulating Fire Brick plus excellent hot and cold strength permits much thinner walls than are possible with ordinary fire brick. Supported walls and suspended arches of Armstrong's Brick provide lower heat storage, accurate temperature control, and much quicker heating and cooling.

TIGHTER JOINTS: Armstrong's Insulating Fire Brick in both standard and special shapes are accurately machine sized and their porous surface texture gives assurance of a firm and lasting mortar bond between brick.

LIGHTER SUPPORTS: Supporting castings can be much lighter because Armstrong's Insulating Refractories are exceptionally light and due to their high thermal efficiency the hangars are subjected to lower temperatures—this also permits the use of lower grade alloys in castings.

WORKABILITY: It is specially advantageous to use Armstrong's Insulating Fire Brick in this type of supported construction because they can be readily cut, shaped, notched, bored, and slotted right on the job—speeding construction and simplifying repairs.

Engineering Service

Qualified Armstrong Engineers will be glad to answer your questions as to the application of the five types of Armstrong's Brick for temperatures from 1600° F. to 2600° F. They offer you facts about the advantages of Armstrong's Insulating Fire Brick in various furnace constructions. Write for information and file-sized folders. Armstrong Cork Co., Building Materials Division, 1001 Concord St., Lancaster, Pa.

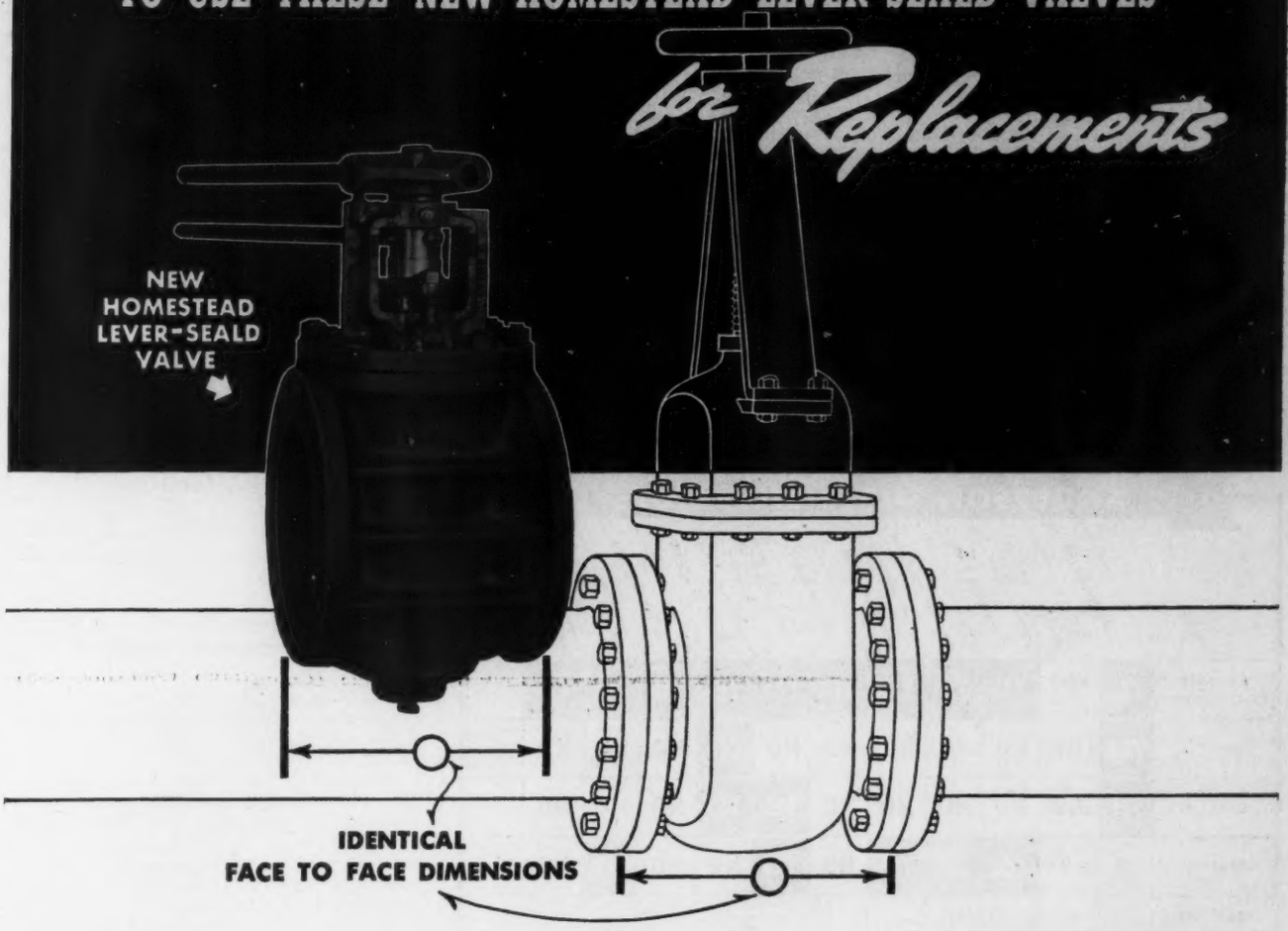
Armstrong's

HIGH TEMPERATURE INSULATION

No Piping Changes...

TO USE THESE NEW HOMESTEAD LEVER-SEALD VALVES

for Replacements



Now you can have the advantages of Homestead Lever-Seald Valves on replacements, without the expense and difficulty of piping changes. Face to face dimensions of this new Homestead series are identical with those of corresponding size wedge gate valves. Simply bolt these new Lever-Seald Valves between present flanges, and your valve troubles end! Powerful leverage gives extra ease of opening or closing under the toughest service conditions. Other advantages include quarter-turn operation, protected seating surfaces, straight line flow, and a leakless seal without lubrication. Available for working pressures from 150 to 800 pounds; a choice of metals and alloys for longest service at lowest cost-per-year. Write your needs for specific recommendations by our engineering department.

For engineering facts about these and other Homestead Valves, write for your copy of Valve Reference Book No. 38.

HOMESTEAD VALVE MFG. COMPANY
P. O. BOX 16 CORAOPOLIS, PA.

HOMESTEAD VALVES

QUARTER-TURN VALVES:
STRAIGHT-WAY
THREE-WAY
FOUR-WAY
LUBRICATED TYPE
LIFT-TYPE PLUG

PROTECTED-SEAT VALVES:
HYDRAULIC (B. & O. PAT.) OPERATING
REMOTE CONTROL
HYDRAULIC DESCALING
ROSS AIR SHUT-OFF VALVES
HOVALCO BLOW-OFF VALVES

surface. In action thousands of small rubber waves open up to create a squeegee effect.

Because of the wide acceptance by yachtmen, U. S. Rubber believed the sole might have extensive application in industry. Special studies were therefore begun to determine which types of workers would be aided by footwear which will not skid, even under water.

A short line has been introduced which includes an all-white patrol rubber, an all-white Terre Haute, a light, short boot, hip length boot, and special marine boot.

Other types are expected to be developed as a result of a continuing study of industrial needs in this line. U. S. Rubber has asked that all companies who have special problems with damp, oily or other slippery surfaces submit them for consideration.

Sight-Feed Lubricator

THE ROTO COMPANY

The Roto Company, 145 Sussex Avenue, Newark, New Jersey, has designed a new sight-feed lubricator for air-driven equipment, which operates automatically regardless of its position in the line. Because it has no baffle it can be turned to any position convenient for visibility.

Another feature of the lubricator is that it requires only a single regulating valve. Oil is added by removing a simple screw plug at the top of the lubricator.

Roto lubricators are installed in an ordinary tee in the air line. They are made in 4/5-pint and quart sizes, and can be regulated to drop as few as 5 drops of oil per minute. While the new lubricator was developed to assure a positive oil feed for the company's tube cleaners, it may also be used with other types of air-driven equipment.

Sight-feed Lubricator

Microphotometer

LEEDS & NORTHRUP COMPANY

Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia, has introduced a recording microphotometer for analyzing spectrographic plates or films in research laboratories.

Because the plates or films are mechanically scanned by a motor-driven scanning unit, and the relative positions and densities of spectrum lines are automatically recorded, this new recording microphotometer eliminates the eye-strain and "human equation" of visual methods, and does away with the delays and limitations of photographic processes. Quick determinations of elements present in small percentages are made possible by pen-and-ink records of standard and test spectrograms drawn at high speed on one chart.

Designed to accommodate plates or

Microphotometer

How good are YOUR steam traps?

Compare them to
ANDERSON SUPER-SILVERTOPS

	Long Service Life	Average Repair Cost	Straight-Line Piping	Low Cost Installation	Easy To Inspect	Guided Bucket	Valve and Seat Easy To Remove	Works on Vacuum	Self-Cleaning Trap	Blowdown at Bottom of Trap	Dependable Snap-Action Air Eliminator	
ANDERSON SUPER-SILVERTOP	YES	VERY LOW	YES	YES	YES	YES	YES	YES	YES	YES	YES	
TRAP "X"	YES	LOW	NO	NO	NO	NO	NO	YES	NO	NO	NO	
TRAP "Y"	YES	LOW	NO	NO	NO	NO	YES	YES	NO	NO	NO	
TRAP "Z"	?	?	YES	YES	YES	NO	YES	NO	NO	YES	NO	
YOUR TRAPS (You fill this in) ?												

Steam trap at the left is an Anderson Super-Silvertop showing simplified piping. View below shows puzzle piping of old style inverted bucket trap.

● Compare your steam traps to Anderson Super-Silvertop. Compare any steam trap to Super-Silvertop and see why thousands of trap users are changing to the engineered inverted bucket steam trap!

Anderson Super-Silvertops are connected either straight-in-line or as an elbow, no extra fittings to buy or install. That means neater piping layouts and a saving of as much as seven fittings and an hour of installation time *per trap!*

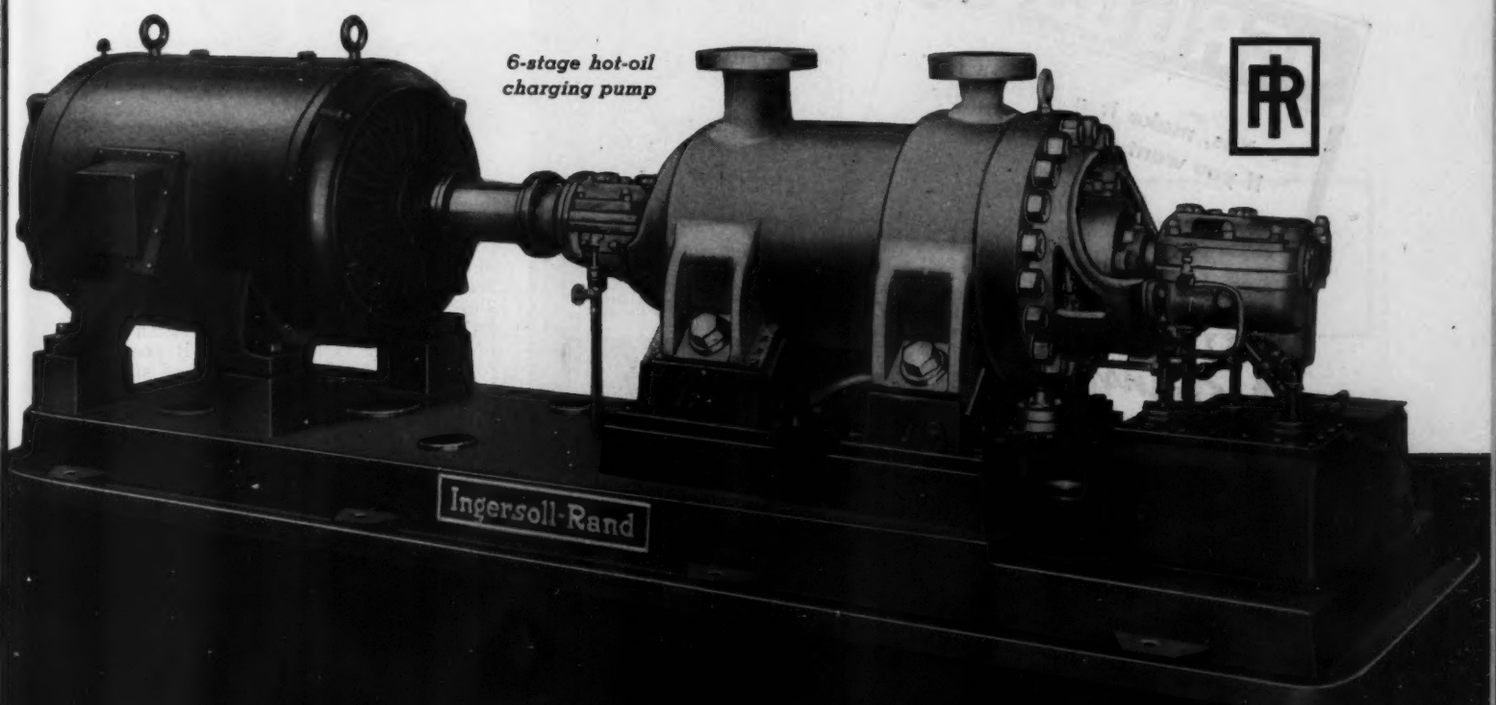
Get all the facts about Super-Silvertop, the long-life inverted bucket trap with simplified piping—send for your free copy of "How To Choose a Steam Trap," a helpful, handy steam trap manual, write today.

THE V. D. ANDERSON COMPANY
1942 WEST 96th STREET • CLEVELAND, OHIO

Super-Silvertop
STEAM TRAPS

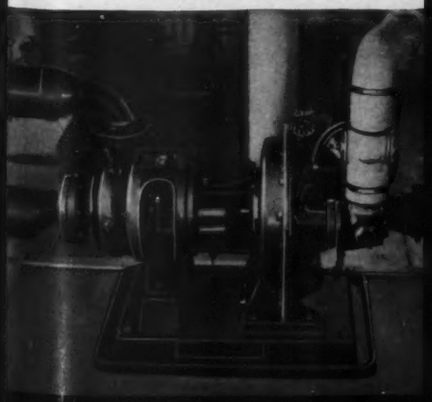
Where Dependability is Vital... *Choose* Ingersoll-Rand Pumps

INGERSOLL-RAND refinery pumps deserve their enviable reputation in refineries in all parts of the world for their dependable trouble-free service. This reputation is the result of the sturdy construction, the attention to construction details and the careful fitting of each pump to its job. The Ingersoll-Rand line of pumps is complete. There are single and multi-stage pumps in both horizontally and vertically split types for every refinery service from pumping water to charging stock under high pressures and temperatures. Ask Ingersoll-Rand engineers for further details.

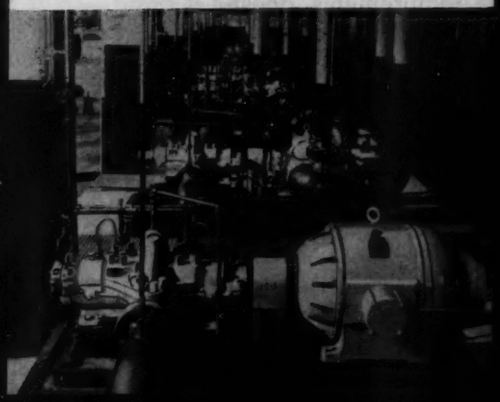


6-stage hot-oil charging pump

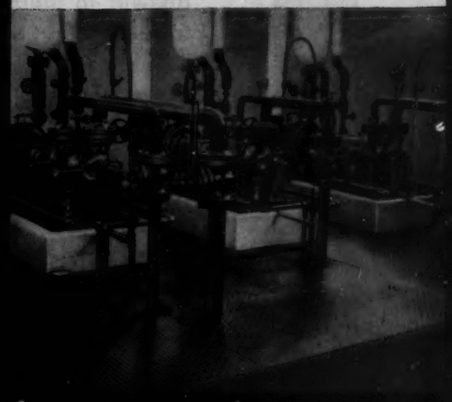
Turbine-driven close-coupled pump in a refinery



Pumps handling cold reduced crude oil



Three pumps in a recycling plant



10-11

Ingersoll-Rand

11 BROADWAY, NEW YORK CITY

Branches or Distributors in other Principal cities the world over.

Atlanta, Birmingham, Boston, Buffalo, Butte, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Duluth, El Paso, Hartford, Houston, Kansas City, Knoxville, Los Angeles, Newark, New Orleans, New York, Philadelphia, Picher, Pittsburgh, Pottsville, Salt Lake City, San Francisco, Scranton, Seattle, St. Louis, St. Paul, Tulsa, Washington

Montreal, Mexico, Havana, Rio de Janeiro, Caracas, Buenos Aires, Lima, London, Paris, Madrid, Lisbon, Melbourne, Calcutta, Johannesburg

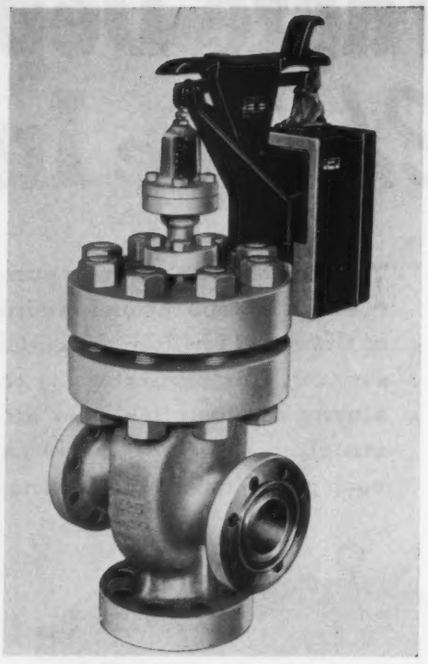
films as large as 4 inches high by 10 inches wide, the unit includes on a heavy cast base, an optical system, a plate stage, a drive mechanism for the plate stage, an a-c operated amplifier and all necessary controls grouped at a convenient location. In indicating and recording relative positions and densities of spectrum lines, the response of the Speedomax recorder to density changes is so immediate and so rapid that in less than 1.5 seconds the pen moves from one position and comes to rest at its new position . . . even across the entire width of the 9-inch chart. Pen position can be read at a glance on an indicating scale as the record is being drawn. No unusual skills are required to operate this new microphotometer.

Power Control Valve

MANNING, MAXWELL & MOORE

Manning Maxwell & Moore, Consolidated Ashcroft Valve Division, Bridgeport, Connecticut, has developed the Ashcroft power control valve for high-pressure installations between 1800 and 2500 pounds.

This power control valve is an automatic relief valve that may be set for a 1 percent or less difference between opening and closing pressure; which effects a large saving over the 4 percent required for the spring-loaded safety valves. The immediate results are more accurately balanced boiler operation at peak loads and more uniform line pressure. In addition, its use reduces spring-loaded safety valve maintenance expense.



Power Control Valve

The regular spring-loaded safety valves rarely pop in service when an Ashcroft power-control valve is used. The power-control valve is set to open at a slightly lower pressure than any of the safety valves, making it possible to continue a more even rate of steaming with a more uniform line pressure.

The principle of operation of the Ashcroft power-control valve is simple. The boiler drum or superheater outlet pressure or steam header pressure actuates a pressure control set at the popping pressure, which operates an electric contact on a difference in pressure of 1 percent or less. The electric current is transmitted to a solenoid which opens and closes the pilot valve. When it opens it unbalances the pressure over the main valve disc and it opens and remains open until the pilot valve is closed. The whole cycle of operation is almost instantaneous. The power-control valve opens exactly at the popping pressure and it closes cleanly with an extremely low blow-down. High superheat temperatures have no effect on its action.

The Ashcroft power-control valve is not intended to replace the spring-loaded safety valve, but rather it is a supplementary operating valve, designed to conserve power and increase the efficiency of the steam-generating plant.

Socket Set

BONNEY FORGE & TOOL WORKS

Bonney Forge & Tools Works, Allentown, Pennsylvania, has introduced a socket set, No. TD12.

Containing 20 strong, lightweight pieces for making practically any combination desired, each one is made of chrome-vanadium steel in the popular ⅜-inch square drive.

It includes a full set of sockets with 5/16-, 3/8-, 7/16-, 1/2-, 9/16-, 5/8-, 11/16- and 3/4-inch double hexagon openings; universal joint; 6-, 12- and 17-inch extensions; 1/2- and 9/16-inch crowfoot attachments; 17½-inch speeder; drag link socket; 8½-inch hinge handle; 6-

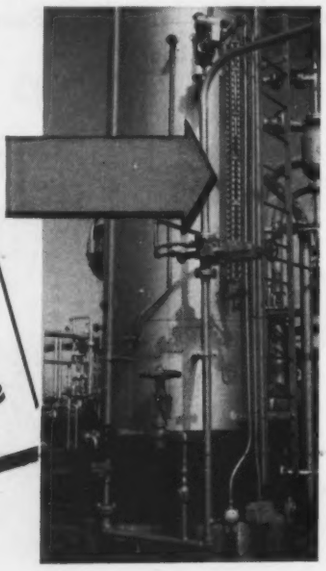
JERGUSON

Yes, make it a Jerguson if you want a strong, sturdy

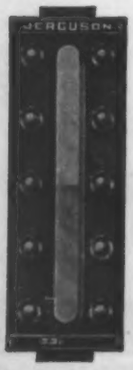
Reflex Gage

. . . and make it a Jerguson if you want a durable, readable

Transparent Gage



Reflex Gage



Transparent Gage

WOULD it interest you to know that right now we are making a large number of special gages for the Navy?

And the gages we make for service in your plant are just as sturdily and carefully made—only the design is different.

Surely if such exacting buyers as those running our first line of defense find in Jerguson the answer to their gage requirements, doesn't it stand to reason that here you will find the answer to yours?

JERGUSON *Reflex* GAGES	JERGUSON *Transparent* GAGES
recommended for Pressures up to 3200 lbs. at 100° F., or Pressures up to 1200 lbs. at 1000° F.	recommended for Pressures up to 2000 lbs. at 100° F., or Pressures up to 600 lbs. at 1000° F.

JERGUSON GAGE & VALVE CO.

87 FELLSWAY, SOMERVILLE, MASS.

11-JV-1

HERE'S THE *Inside Story* OF A WALSEAL FITTING...

"It's a Silver-brazed joint — not a soldered joint."
"When the silver fillet appears the joint is made. Finished joint is strongest part of the line!"
"It's easy to make. Brazing alloy is inserted at the Walworth factory."

THE MODERN FITTING designed to IMPROVE BRASS AND COPPER PIPING

A Walseal Fitting is a threadless bronze fitting with a ring of brazing alloy – Sil-Fos – incorporated in each port opening. It is used to join brass or copper pipe, or Type B copper tubing, and the resulting joint is known as a Silbraz Joint.

A finished Silbraz Joint – brass or copper – is stronger than either the pipe or fitting with which the joint is made. A Silbraz Joint cannot creep or pull apart under any temperature to which the pipe or tube can be safely subjected. Moreover, a Silbraz Joint is leakproof, corrosion resistant, vibration proof, and easy to install. The correct amount of brazing alloy is inserted in each Walseal Fitting at the Walworth factory. To install, simply cut the pipe, clean and flux the pipe-end and fitting-bore, assemble, and braze with an oxyacetylene flame.

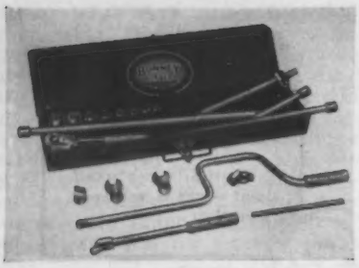
Remember, a Silbraz Joint is a silver brazed joint,–*not a soldered joint.* Bronze Valves and Flanges having Walseal features are also manufactured by the Walworth Company. For further information see your nearest Walworth distributor or write for illustrated circular #46.

WALWORTH

WALWORTH COMPANY
60 EAST 42nd STREET, NEW YORK

VALVES FITTINGS and TOOLS
Backed by 99 Years' Service

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD



Bonney Socket Set

inch cross handle; 7-inch reversible ratchet and 8-inch sliding "T."

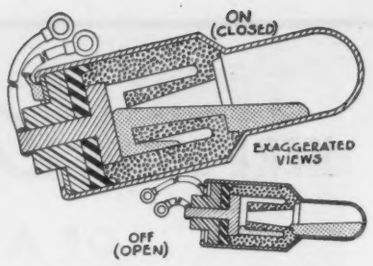
Every piece is carefully heat treated to bring out the ultimate strength of the steel and provided with a lasting, rust-resistant finish.

Mercury Switch

DURAKOOL, INC.

Durakool, Inc., 1010 North Main Street, Elkhart, Indiana, has designed a mercury switch for preventing double contacting where vibrations exist. It is designated "Double-Flow and has the peculiar characteristic at the time of opening and at the time of closing of rejoining of the two bodies of mercury.

When the large end tips slightly above level, the horseshoe-shaped mercury pulls down on either leg, putting the central part of the mercury under tension, much as you would pull a rubber band down across a sharp edge, so that when the parting takes place neither body can reach over and reconnect with the receding, opposite body.



Double Flow Mercury Switch

This avoids double contacting so prevalent where vibrations occur just at the moment of operation.

When the large end starts to tip back to the closed position, the two separate legs of the horseshoe crowd toward a common joining point, and the mercury in a long channel compresses the advancing points so that when the two do meet they become confluent with a level twice as high as they would have if it were but one moving body of mercury contacting a stationary body.

TODAY You Need the FASTEST TUBE CLEANERS

Down time for cleaning tubular equipment is awfully expensive right now. You need the fastest and most dependable cleaners money can buy, especially since the entire cost of such cleaners is insignificant compared with the value of the equipment tied up.

Now, more than ever, the exclusive time and labor saving features of the new Roto Tube Cleaner will pay you a handsome return on your investment. The powerful new Roto cleans out coke, carbon, sludge and scale faster than ever before possible. The exclusive air valve on the motor enables the operator to work entirely by himself, saving the cost of a helper and eliminating starting and stopping delays between every tube cleaned. High quality alloys and precision construction make the new Roto the most economical for upkeep of any cleaner we ever made.

Just compare the new Roto with any other cleaner in your plant.

SEE OUR ADV. IN SWEET'S AND WRITE

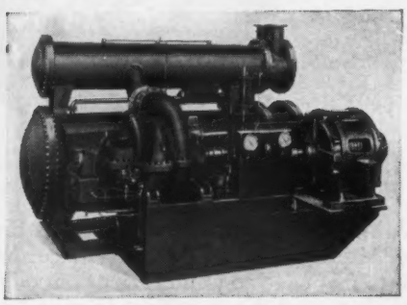
The ROTO Company
145 SUSSEX AVENUE
NEWARK, N. J.

ROTO TUBE CLEANERS

Liquid Cooling Systems

WORTHINGTON PUMP & MACHINERY CORPORATION

Worthington Pump & Machinery Corporation, Harrison, New Jersey, has developed a new line of liquid cooling systems for industrial process requirements. The centrifugal compressor is of the volute design as opposed to the diffuser design previously used in centrifugal refrigeration.



Liquid Cooling System

Among the new features of the design are dual lubrication, balancing of end thrust and side thrust by arrangement of impellers and volutes. The systems are available over a range from 150 tons to 1200 tons per day of refrigeration capacity.

Double Row Gauge Cocks

THE INFERNO COMPANY

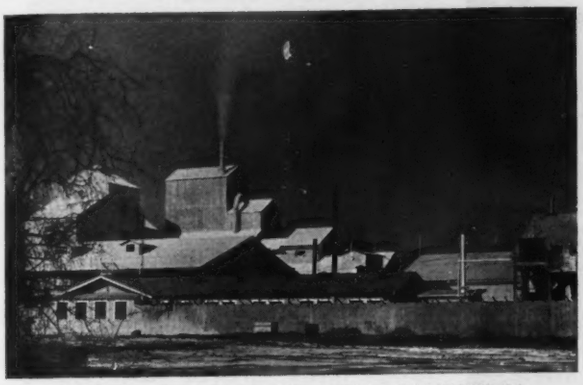
The Inferno Company, Shreveport, Louisiana, has improved its line of gauge cocks to give them twice the number of seats as previously provided. Two rows of seats can now be made on each side of the reversible seating disc by changing the pin to the extra hole in the handle bracked.

They are available with shanks of drop forged 18-8 stainless steel, S.A.E. No. 3140 steel, and navy bronze. The

Reversible Gauge Disc

Oil is the Lifeblood of Defense

FILTROL PLANT AT JACKSON, MISSISSIPPI



FILTROL PLANT AT VERNON, CALIFORNIA

FILTROL PRODUCTS give these advantages:

MAXIMUM DECOLORIZING EFFICIENCY
MAXIMUM FILTER RATE
MINIMUM CLAY REQUIREMENTS
MINIMUM PLANT EQUIPMENT

FILTROL'S two great plants are doing their part to make this oil BETTER

Conveniently located in Jackson, Mississippi, and Vernon, California, FILTROL'S two plants are providing refiners with much needed supplies of SUPER FILTROL bleaching earth, enabling them to turn out a superior quality of lubricating oil for the nation's needs.

We salute the bombers that patrol our American shores, the ships that carry vital supplies to the beleaguered nations, the destroyers that police the submarine infested waters of the Atlantic . . . To all of these and to the defense industries at home we send assurance that FILTROL is doing its part to see that they receive vital lubricating oil of the very finest quality.

FILTROL CORPORATION

GENERAL OFFICES:
315 WEST FIFTH STREET
LOS ANGELES, CALIF.

PLANTS:
VERNON, CALIFORNIA
JACKSON, MISSISSIPPI

CABLE ADDRESS: FILTROL·LOS ANGELES

AGENTS AND WAREHOUSE STOCKS IN PRINCIPAL REFINING CENTERS OF THE WORLD

stainless steel and the No. 3140 steel are guaranteed to never break or twist off in the boiler, and are suitable for pressures up to 1000 pounds. The navy bronze is suitable for pressures up to 350 pounds. An interesting laboratory test conducted by the manufacturer revealed that the gauge cocks would remain firmly seated until subjected to more than 3000 pounds hydraulic pressure.

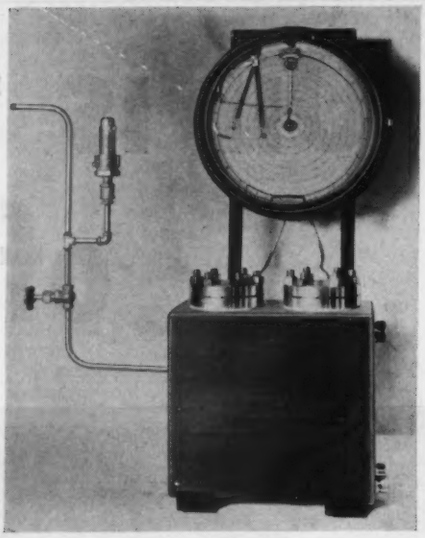
It is claimed the gauge cocks are balanced so that any sliding motion of the nozzle tip on the seating disc is eliminated. The generous diameter of the seating disc deflects the steam away from the operator. The seating disc is made of hard, durable copper, and the hardened stainless steel nozzle tips are renewable.

Oxygen Bomb Recorder

THE FOXBORO COMPANY

The Foxboro Company, Foxboro, Massachusetts, has released the following information on its design for the Universal Oil Products oxygen bomb test recorder:

"The equipment consists of a rectangular stainless steel box containing one, two or four stainless steel bombs, each of suitable size to accommodate an 8-ounce oil sample bottle. The bomb box is heated with steam and cooled with water. The head of each bomb has a ground V-joint which is fitted in such a manner that a gasket is not required. The head is held in place by six bolts with hexagonal nuts. The flange at the top of the bomb is tapped and a flexible copper tube connects the bomb with a



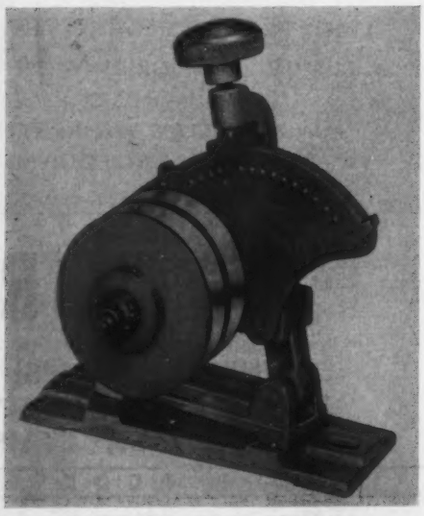
Oxygen Bomb Recorder

Foxboro Pressure Recorder. The Recorder has a separate pen for recording the pressure in each bomb. As many as four pens can record, simultaneously, in the same chart area without interference."

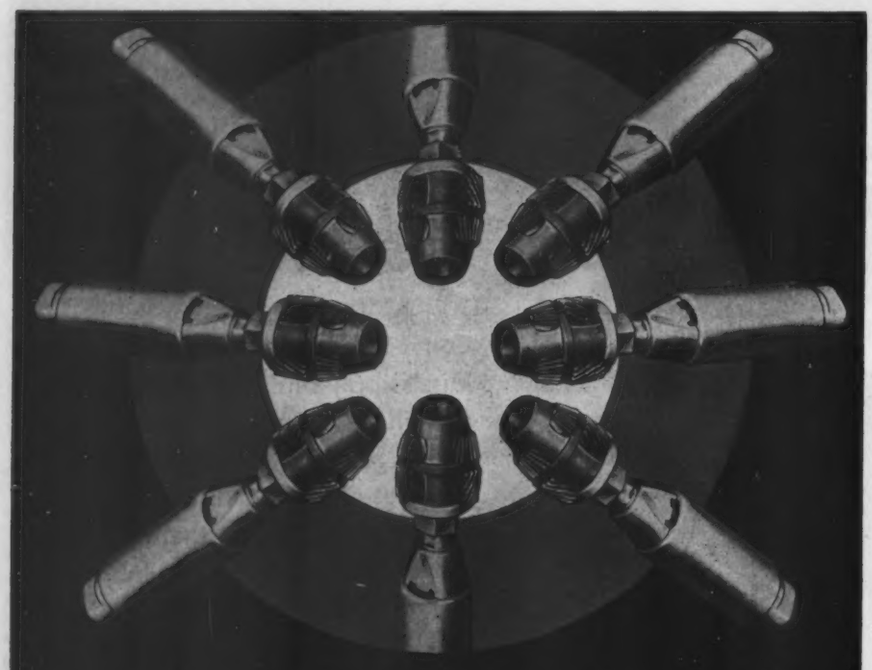
Variable-Speed Controller

STANDARD TRANSMISSION EQUIPMENT COMPANY

Standard Transmission Equipment Company, 417 West Eighth Street, Los Angeles, has introduced a new V-belt variable-speed transmission to its line of equipment. The JFS-CUB is especially designed for all A section V-belt applications and for speed ranges up to 3.3-1. Smooth sided pulleys are used rather than the interlocking type. Among the advantages claimed are: the patented positive belt alignment feature which makes possible mounting in any and every position without impairing function or throwing belts out of alignment; machined and balanced cast iron construction, forged lubrication of the special bronze bearings on which the pulleys rotate; free-end pulley spindle to permit easy installation of belts; both pulleys on one side of pivotal mechanism which permits motor pulley and driven



Variable Speed Controller



For *CLEANER* TUBE CLEANING SPECIFY A WILSON CLEANER!

The *cleaner* still tubes—and other refinery tubes and pipes—can be cleaned, the *longer* the still or other unit can be on stream before another cleaning is necessary. The *faster* tubes can be cleaned, the *sooner* the unit is again in operation.

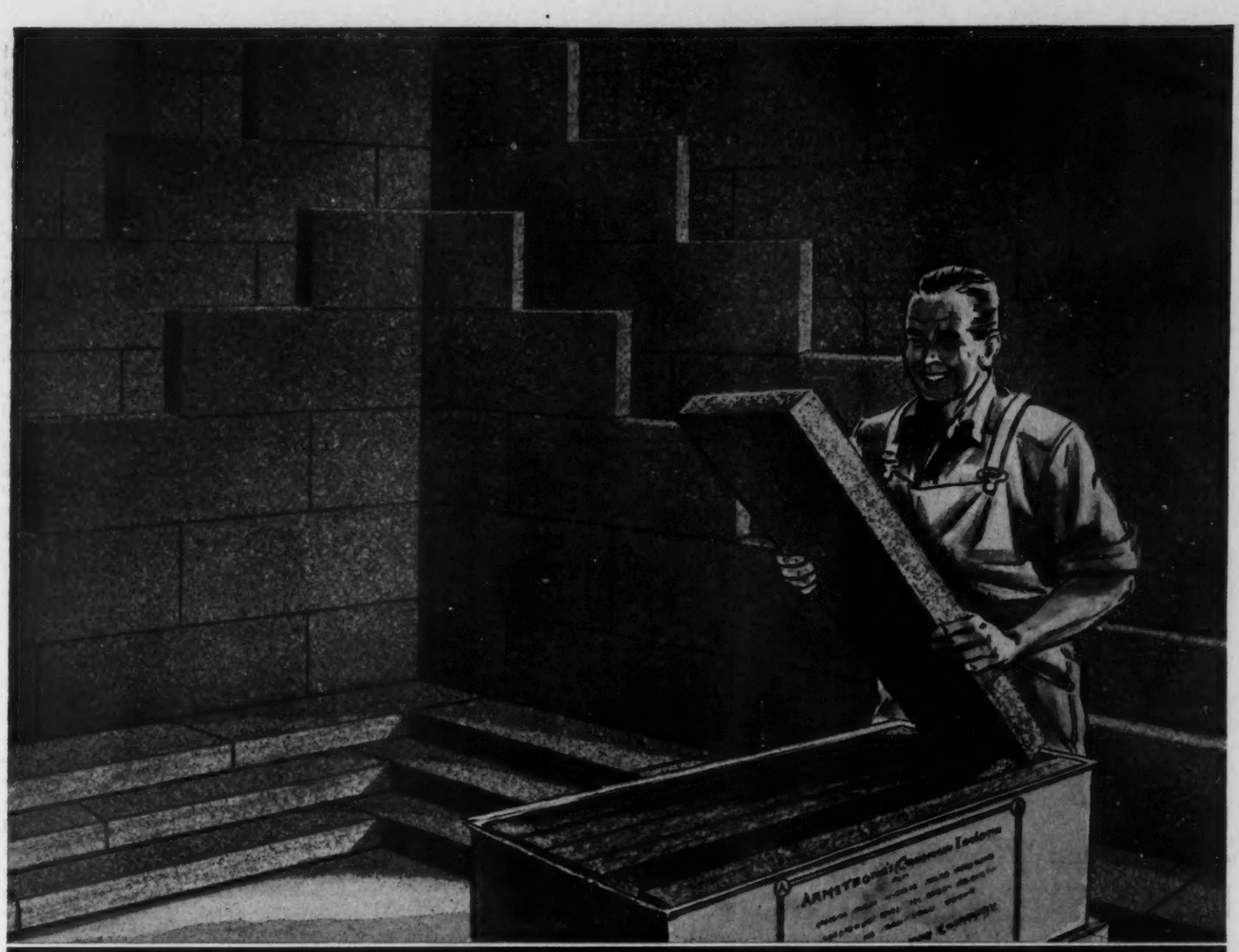
Wilson E P (Extra Power) Tube Cleaners have that *extra power, extra speed,* and *extra efficiency* which enable them to clean tubes *cleaner* and *in less time.* A Wilson E P Cleaner and the proper Wilson cutter head or other accessory will *rapidly* and *thoroughly* remove extremely hard, heavy, or gummy deposits and *reduce* down-time and *increase* production and profits.

Write for the name of our representative nearest to you or send for a copy of our thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.

PIPE AND TUBE CLEANERS EXCLUSIVELY

47-28 37th Street Long Island City, N. Y.



CORKBOARD insulation is again AVAILABLE

THE cork supply situation is much improved. Cork is still under OPM control but the Government's reserve stock pile, to care for emergency requirements in the event Spanish and Portuguese ports are closed, has been substantially increased. This means that shipments now arriving can be utilized to meet most needs for corkboard insulation, first for defense work and then for work involving food preservation. Restrictions on the use of corkboard for insulating roofs and air conditioning ducts still apply.

Whatever may be your needs for low temperature insulation, get in touch with your Armstrong Cork man. Let him know how much corkboard you need, how it will be used, and when you will want it delivered. We expect to be able to make prompt delivery of all usual quantities dependent upon continued favorable shipping conditions and upon Government requirements. We will be glad to give you information quickly about your specific needs.

Get in touch with us early . . . if possible even before drawings are prepared . . . so that our insulation specialists will have time to work out your problem with you in the most effective way. This early information will help us to give you the best possible delivery service.

Prompt Delivery of CORK COVERING

Armstrong's Cork Covering for cold lines and fittings is used largely in defense plants or in plants requiring refrigeration to protect perishable foodstuffs. Due to this fact and because the relatively small amount of cork used has not hindered the Government's cork reserve program, we can meet practically all needs for cork covering promptly. This insulation is made in sizes for all standard piping.

For information on deliveries of corkboard and cork covering call our nearest office or distributor, or write direct to Armstrong Cork Company, Building Materials Division, 1001 Concord Street, Lancaster, Pa.

ARMSTRONG CORK COMPANY
Insulation Headquarters

★ CORKBOARD ★ CORK COVERING ★ FIBERGLAS* ★ TEMLOK ★ INSULATING FIRE BRICK ★
*Reg. U. S. Pat. Off. O.-C. F. Corp.

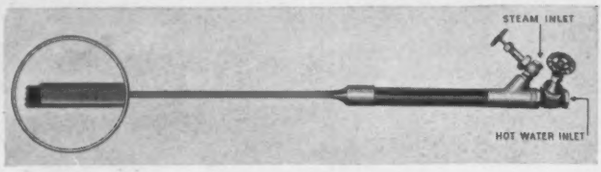
pulley to be almost directly in line with each other; etc.

The JFS-CUB is being introduced as a low-cost speed control to make possible application on machines that never before could have the advantages of infinite speed selection because of expense. It will transmit full capacity of A section V-belts, and can be used with all machines now using that size.

Bundle Cleaning Lance

THE AIRETOOL MANUFACTURING COMPANY

The Airetool Manufacturing Company, 200 Shuey Building, Columbus, Ohio, has designed a tool for the cleaning of heat-exchanger bundles. It is offered as a device for removing deposits from spots which are difficult to reach.



Tube Cleaning Lance

It can be used in all cases where tube rows have a square pitch, the usual space between these tubes being ¼-inch minimum. Effective length of the lance is 30 inches and it may be entered from either side.

Hot water or chemical solution is applied through 1-inch main valve and steam through the ½-inch valve at the side with a jet in Y fitting to provide proper mixing. The handle is insulated for safety and convenience in handling.

Steam Trap

W. H. NICHOLSON & COMPANY

W. H. Nicholson & Company, Wilkes-Barre, Pennsylvania, has introduced the Nicholson Industrial Steam Trap, Type AHV, which operates thermostatically by utilizing the temperature difference between steam and condensate to close

Nicholson Steam Trap

the valve. The trap is of the bellows type but is sturdily designed for high pressures and severe service, with high water and air discharging capacity and positive intermittent valve action.

Acid Mask

E. D. BULLARD COMPANY

E. D. Bullard Company, 275 Eighth Street, San Francisco, has introduced a new mask which gives complete head and neck protection to workers handling acid and other dangerous solutions. The shatter-proof laminated goggles fit snugly around the eye cavities so that the hood cannot slip or turn. This feature assures good vision when the head is turned in any position.

The live-rubber goggle mounting is provided with inbuilt air vents of the indirect type that prevents splattering liquids from entering, yet keeps lenses from fogging under normal working conditions.

Form-fitting shoulders offer full neck and chest protection. There is ample impregnated cloth in the mask to tuck into other clothing, so that all vital parts of the body are protected. Seams are double stitched—then rubber cemented to add longer wear. This hood does not provide respiratory protection.

Rotary Pumps

BLACKMER PUMP COMPANY

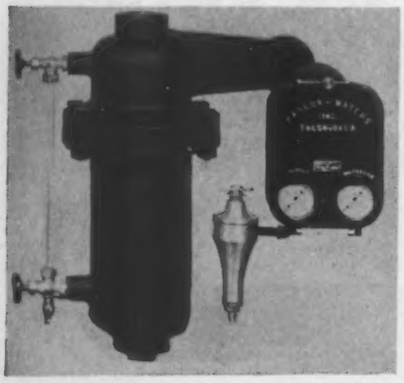
A line of rotary pumps designed for use with hydraulically operated machinery and other industrial applications, available for pressures up to 150 pounds and capacities from 50 to 700 gallons per minute, has been announced by Blackmer Pump Company, Grand Rapids, Michigan.

Standard units are furnished in reduction-gear drive, gearhead motor and V-belt drive, while standard constructions are of all iron, bronze-fitted, or all bronze. Pumps for lubricating liquids may be obtained with internal roller bearings, while external roller bearings are furnished on pumps for handling non-lubricating liquids. Pumps employing external roller bearings are equipped with mechanical seals to eliminate stuffing boxes.

Wall Coating

THE BERGONIZE COMPANY

The Bergonize Company, Merchandise Mart, Chicago, is offering a washable covering for wall surfaces. The product applies readily to a painted or cleaned wall and leaves a transparent protective film which prevents dirt and grime from penetrating the paint. It dries within 20 minutes at 70° F. One gallon covers 1500 square feet. It can be removed by clear water, taking away all dirt.

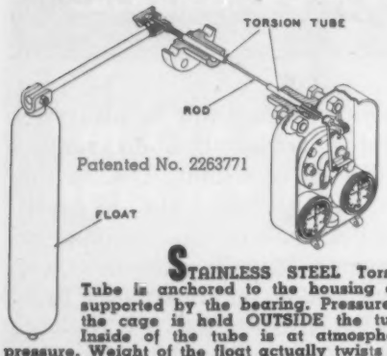


Ask the Men Who Operate

HANLON-WATERS Type 850

"Displacement Type"

LEVEL CONTROLLER



STAINLESS STEEL Torsion Tube is anchored to the housing and supported by the bearing. Pressure in the cage is held OUTSIDE the tube. Inside of the tube is at atmospheric pressure. Weight of the float actually twists the tube. Rising level reduces the effective weight of the float, causing tube to partially return to its normal position. The rod welded at the float connection transmits the rotation to the pilot mechanism.

THE **ONLY** LEVEL CONTROLLER WITH **NO** STUFFING BOX . . . . . LEAKAGE . . . . . FRICTION

Information on all HANLON-WATERS Equipment available at representative nearest you

HANLON-WATERS, INC.

TULSA, OKLAHOMA

New York, Chicago, Pittsburgh, Philadelphia, St. Louis, Denver; Shreveport and Lafayette, La.; Fort Worth, Houston, Corpus Christi, Longview and Odessa, Texas.

GASKETS

"MELRATH"

"MELOIL"

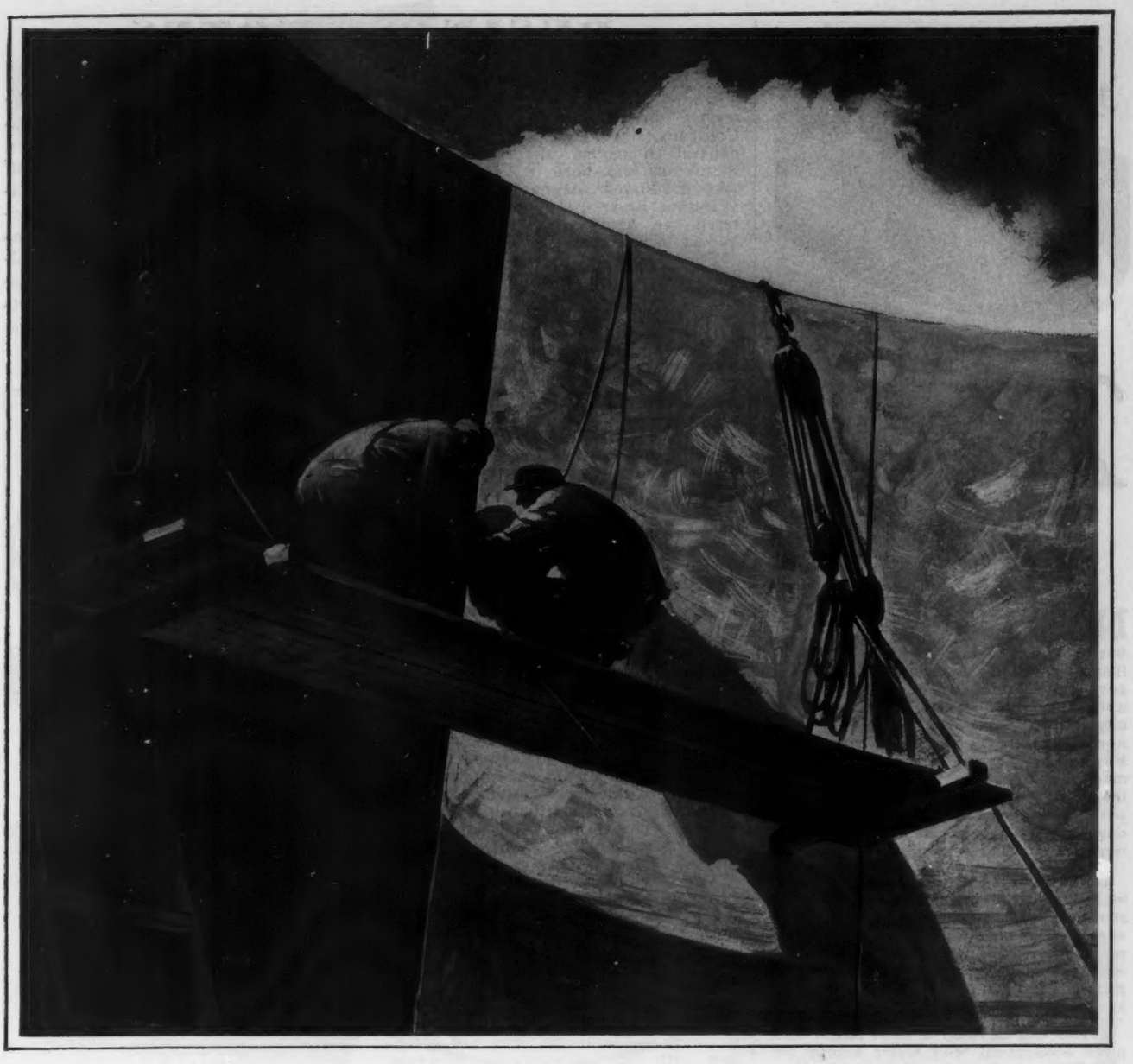
"MELBESTO"

- **We make gaskets in steel, copper, lead, monel metal stainless steel, Armco iron, aluminum, nickel, fibre, rawhide, rubber or any other material. Plain, corrugated or perforated metal. Metal-asbestos and other combinations; to suit any use—for gasoline, acids, oil, chemicals, alcohol, steam, ammonia, etc. Any size, shape, quantity.**

MELRATH

SUPPLY & GASKET CO., INC.

Tioga & Memphis Sts., Phila., Pa. Est. 1900



TEACHING HUNGRY ACID TABLE-MANNERS

HANDLING corrosive acid is like feeding a lion. You want it to eat — but not to bite the hand that feeds it.

In short, you want *Tellurium Lead.*

This new alloy resists the bite of corrosive acids even at temperatures close to the melting point of the metal. Thus it prolongs the life of tank linings, heating coils and pipe lines, cuts down shutdowns for repairs and also makes for safer working conditions.

Strengthens under Stress: A tough lead to begin with, Tellurium Lead actually gets *tougher* when rolled, stretched or hammered. As a result, turnover points and joints are less subject to cracking. Further, this capacity to "work-harden" minimizes buckling and creeping—important where vibration occurs—and also gives Tellurium Lead greater resistance to fracture from repeated heat changes.

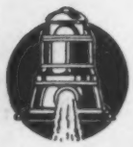
Tellurium Lead of our manufacture is time-tested St. Joe chemical lead, alloyed with a small quantity of tellurium. It gives the advantages of this well-known chemical lead plus important new ones. Yet now costs only a fraction of a cent more per pound than chemical lead. Available in sheets, pipe and coils. For further facts, write our nearest branch, listed below.

TELLURIUM LEAD

NATIONAL LEAD COMPANY—New York, Baltimore, Buffalo, Chicago, Cleveland, Cincinnati, St. Louis; National-Boston Lead Co., Boston; John T. Lewis & Bros. Co., Philadelphia; National Lead & Oil Co., Pittsburgh; Georgia Lead Works, Atlanta; American Lead Corp., Indianapolis; Master Metals, Inc., Cleveland; The Canada Metal Co., Ltd., Toronto, Montreal, Winnipeg, Vancouver.

"Best Well Ever Installed"
Said Clintonville, Wisconsin

2,000,000
Gallons Daily



NEVER in its history had Clintonville, Wisconsin been able to obtain more than 250 gallons of water per minute from any of a number of their wells. The city was growing and the need for a larger supply of water was becoming urgent. Layne Hydrologists made a survey, a contract was closed and the result is a well producing 1400 gallons per minute, or over 2,000,000 gallons per day. Thus again Layne has been outstanding in success where others have failed.

Layne installed their famous gravel wall well—a type of installation that size for size and depth for depth usually doubles and often quadruples the amount of water produced from a given formation. They differ materially from the so called "gravel packed" well and are the most efficient known.

Layne can develop a new, larger and more economical well water supply for you. They can do the work promptly, thus expediting your expansion and production plans. Why not ask Layne to give you further details. For literature, address

LAYNE & BOWLER, INC.
Memphis, Tenn.

LAYNE
PUMPS & WELL
WATER SYSTEMS

Affiliated Companies

Layne-Arkansas Company.....Stuttgart, Ark.
Layne-Atlantic Company.....Norfolk, Va.
Layne-Central Co.....Memphis, Tenn.
Layne-Northern Company.....Mishawaka, Ind.
Layne-Louisiana Company.....Lake Charles, La.
Layne-New York Co.....New York City.
Layne-Northwest Company.....Milwaukee, Wis.
Layne-Ohio Company.....Columbus, Ohio
Layne-Texas Company.....Houston, Texas.
Layne-Western Company.....Kansas City, Mo.
Layne-Western Co. of Minn.....Minneapolis, Minn.
Layne-Bowler New England Corp...Boston, Mass.
International Water Supply, Ltd...London, Ont.

WORLD'S LARGEST WATER DEVELOPERS

BUSINESS NOTES

Herman W. Steinkraus, vice president and a director of Bridgeport Brass Company since 1928, has been elected general manager of the company. Steinkraus was born in Cleveland. He was graduated magna cum laude at Western Reserve University. He entered the Army as a private in the World War and rose to captain.

For a number of years he was sales manager of Osborn Manufacturing Company, Cleveland. In 1924 he resigned that position to start his own metals and chemicals business. He sold his business to Bridgeport Brass Company and became its general sales manager June 1, 1928. A few months later he was elected vice president in charge of sales and a director, which position he held until January, 1941. At that time, because of the illness of Ralph E. Day, president and general manager, Steinkraus was placed in active charge of the business. In addition to Day, who continues as president of the company, the other officers are: Herbert W. Jones, vice president in charge of finance; William R. Breetz, treasurer and assistant secretary; Rowley W. Phillips, secretary, and Everett Japp, assistant treasurer.

A detailed description of the activities of the five companies which comprise Air Reduction Company, Inc., has been prepared and made available to all stockholders. The purpose of the publication is to acquaint stockholders and others with the many activities and the many products in which the concern engages. The company has almost 2½ times as many stockholders as employes, who number more than 6100.

The 55 pages of the loose-leaf publication are illustrated with pictures and diagrams and describe the methods, markets and nature of the business, which is basically the separation of air into component gases, which are available for industrial, commercial and medicinal uses.

The trade names under which these products are sold are often not identified with the five operating concerns, Air Reduction Sales Company, National Carbide Corporation, Wilson Welding and Metals Company, Pure Carbonic, Inc., and The Ohio Chemical & Manufacturing Company.

Condenser & Heater Manufacturing Company has been organized with headquarters at 220 Delaware Avenue, Buffalo, New York. The concern will manufacture heat exchange and vacuum equipment. The organizers are S. C. Ross, F. D. Berkeley and H. M. Graham. A branch office has been opened at 420 Lexington Avenue, New York.

Vinson Supply Company, Tulsa, has opened a branch office in the Rule building, Amarillo, Texas. W. Dow Perry will be in charge of this territory. The concern now has four offices, Tulsa, Dallas and Odessa, in addition to the new outlet. Stocks are carried at Tulsa and Odessa. The company represents Fisher Governor Company, Chase Brass & Copper Company, Tube-Turns, Inc., and National Tube Company.

Dr. Charles E. Lucke has joined the staff of Chemical Construction Corporation, New York, as consulting engineer. He will continue to serve on the staff of Columbia University as Stevens professor emeritus of mechanical engineering but will devote most of his time as a consultant in the selection and installation of power-generating and mechanical equipment for the large projects now under construction by Chemical Construction Corporation.

HELP WANTED

Instrument Engineer wanted for responsible position in oil refinery application work. Preferably qualified to analyze control problem from engineering flow plan, determine loads and pressure drops from process data, select proper equipment and specify for purchase. Knowledge of Foxboro, L. & N., Brown, Mason-Neilan and Taylor controls essential. Age approximately 26-30. Engineering degree required. Location New York City. Employment permanent. Advancement pending ability. Pay $250-$300 per month. Address reply to: Box 22-A, c/o THE REFINER, Houston, Texas.

FOR SALE

For Immediate Delivery

Two New 26-lb. natural gasoline storage tanks of 25,000 gallons capacity each, 10′ diameter by 40′ long shell with hemispherical heads, complete with 3′ high support saddles, all necessary connections, tanks built in accordance API-ASME code of new material in September, 1941, have never left fabricating plant and may be inspected before shop painted. Price f.o.b. Shreveport, Louisiana, $3,100.00 each.

Box 777, c/o The Refiner, Houston, Tex.

QUICK REPAIRS ON
CONDENSERS
and
HEAT EXCHANGERS

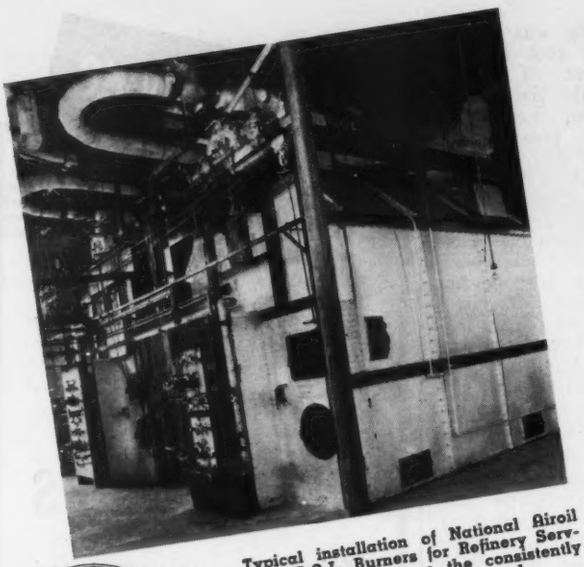
If you need condenser or heat exchanger repairs **in a hurry** call us. We specialize in fast, high quality work.

25 Years Successful Experience

GULF ENGINEERING CO., INC.

"Service, Not Promises"

7014 NAVIGATION BLVD. HOUSTON, TEXAS
916 S. PETERS STREET NEW ORLEANS, LA.



Typical installation of National Airoil Type S.A.L. Burners for Refinery Service. Typical also are the consistently high efficiencies obtained.

80% BOILER EFFICIENCY!

. . . when generating at 15,000 lb. per hour with feedwater at 210 deg. and **without heat recovery devices** . . . 79.4% when generating at 18,000 lb. per hour!

That's the record of two new boilers installed with National Airoil Type S.A.L. Burners in a prominent Canadian refinery. Refinery gas, oil and pitch are used as fuel—**burned singly or in combination.**

For 29 years the National Airoil Burner Company has specialized in burning liquid and gaseous fuels with utmost efficiency. In its complete line of equipment for Refinery service you're sure to find the answer to your burner questions. Just drop us a note describing your problem and we'll be glad to advise you . . . without obligation, of course.

NATIONAL AIROIL BURNER

COMPANY, INCORPORATED
1254 East Sedgley Avenue
PHILADELPHIA, PENNA.

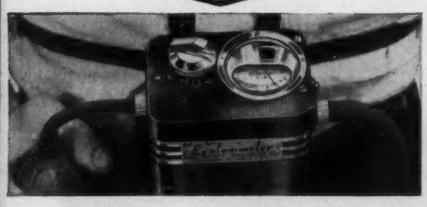
Know your

COMBUSTIBLE GAS HAZARDS—

AT ANY PLACE IN THE

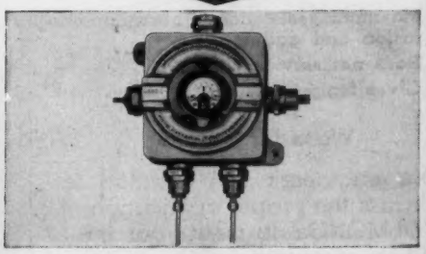
REFINERY

THE M. S. A. EXPLOSIMETER *Model 2*



For accurate gas determination at the working point, this compact, portable combustible gas indicator provides simple one-hand operation,—with other hand entirely free to handle sampling line or probe. Major features are: easy-reading meter, one-piece flow system, On-Off signal bar, separate battery compartment, extra-long battery life with standard flashlight batteries. Complete details in Bulletin No. DN-4.

THE M. S. A. EXPLOSION-PROOF COMBUSTIBLE GAS ALARM



For continuous sampling of surrounding atmosphere where combustible vapors may be present. Provides instant warning when gas concentrations exceed a pre-determined limit, and is completely contained in an explosion-proof case, including integral pump of unique design. Adjustable without opening case. May be adapted for automatic ventilation control or process control. Write for Bulletin No. DT-2.

MINE SAFETY APPLIANCES COMPANY

BRADDOCK, THOMAS AND MEADE STREETS · PITTSBURGH, PA.

District Representatives in all Principal Cities

Sure! They are worn. They've had tough going these last few months. But there's no need to scrap them.

You can resurface those worn parts, at very low cost, with the proper grade of COLMONOY, and the parts can not only be used again but they will outwear and outperform unsurfaced parts many times over.

COLMONOY is the easiest of all hard-surfacing alloys to apply. There is a grade for every hard surfacing requirement. Use COLMONOY to recondition worn pump sleeves, rings and plungers, wash pipes, and all parts subject to excessive corrosion and abrasion.

12 Proven Reasons Why You Should Specify Colmonoy Hard Facing Alloys

1. **Can be applied to all ferrous base metals.**
2. **Easiest of all hard facing alloys to apply.**
3. **Less pre-heating required.**
4. **Has lower melting point.**
5. **Flows more smoothly.**
6. **Less welding time required.**
7. **Can be hot wiped into shape.**
8. **Less hard facing material required.**
9. **Finishes to high polish, minimizing friction.**
10. **Maximum resistance to abrasion, corrosion and galling.**
11. **Does not service check.**
12. **Gives longer life.**

Write for Catalog

Our engineers will be glad to discuss the proper application of COLMONOY to meet your individual requirements. Your letter will receive prompt attention.

WALL-COLMONOY CORP.

Sixth Floor, Buhl Bldg., Detroit, Mich.

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123 W. Philadelphia St., WHITTIER, CALIF.
558 W. 54th St., NEW YORK
208 Midco Building, TULSA
21 Seneca St., BLASDELL, N. Y.

COLMONOY
Hard Surfacing Alloys and Overlay Metals

J. A. O'Brien

John A. O'Brien recently was elected to the post of vice president of Johns-Manville Sales Corporation, Lewis H. Brown, president of Johns-Manville, announced. O'Brien will continue his duties as general sales manager of the power products and industrial department, a post he has held since 1938. He is a member of the J-M Quarter Century Club, having begun his career with the company in 1915. He also is a member of the Engineers Club, New York.

W. J. Thomas, who has been in the process equipment division of The Babcock & Wilcox Company at Barberton, Ohio, has been transferred to the executive department of the sales of Babcock & Wilcox Tube Company, Beaver Falls, Pennsylvania. He has been with the company nine years, previous to which he was with Petroleum Iron Works Company, Sharon, Pennsylvania, as assistant sales manager. He is a graduate of Carnegie Institute of Technology, class of 1922.

Top award in the industrial classification at the sixth annual modern plastics competition went to Oliver United Filter Corporation, Oakland, California, on its Acid Pump Impeller and Filter Drum Segment.

C. B. Dushane, Jr., has been promoted to the managership of the Mid-West territory for American Meter Company with headquarters at Chicago. He has been with the concern and its subsidiaries 21 years.

After World War I when he was in the naval aviation service, he joined Maryland Meter Works division of the company. From there he was transeferred to the Chicago office where he was representative, engineer and assistant manager.

His education was in public and private schools of Baltimore with college work in the Baltimore Institute of Technology, Johns Hopkins University and Massachusetts Institute of Technology. He is a member of the American Gas Association, a past president of the Mid-West Gas Association and member of associations for Illinois, Indiana, Michigan, and Wisconsin.

C. B. Dushane, Jr.

MONEY SAVING *News* FOR REFINERIES AND PRODUCERS

LOW-COST WAY TO REDUCE FIRE HAZARDS

Maintaining uninterrupted production of oil and oil products is the biggest Defense job before refineries today. One thing . . . watch out for fire . . . and the things that cause it. When doing maintenance cleaning, don't take chances! Avoid flammable materials! Use instead, fast, SAFE, low-cost Oakite cleaning.

For example, a solution of recommended Oakite material, applied with the Oakite Solution-Lifting Steam Gun, quickly removes flammable grease, oil and grime accumulations from tractors, derricks, bubble caps, pumps and other producing and refining equipment.

Save Time . . . Money ON THESE JOBS, TOO!

Want money-saving help on such other jobs as de-scaling Diesel engine cooling systems, washing oil drums, cleaning "lube" oil coolers? Write us today . . . we'll be glad to help. No obligation, of course!

OAKITE PRODUCTS, INC.
50B Thames Street, New York, N. Y.
Representatives in All Principal Cities of the United States and Canada

OAKITE *Certified* **CLEANING**

Ickes Gives Industry War Assignment

A special supplement to the

REFINER AND NATURAL GASOLINE MANUFACTURER

December, 1941

Ickes Gives Industry War Assignment

In reply to a letter from the publisher of THE OIL WEEKLY, the Petroleum Coordinator gives data on production needs for 1942 — Discusses number of wells to be drilled — Calls for increased operating efficiency — Points out need for exploration campaign — Discusses above-ground stock situation — refers to refining and transportation problems — Tells of work being done on priorities and stresses need for best utilization of materials

(THE OIL WEEKLY, devoted to the producing-pipe line industry, is a companion publication to The Refiner & Natural Gasoline Manufacturer.)

REPLYING *to a letter dated November 12 addressed to the Petroleum Coordinator by Ray L. Dudley, publisher of* THE OIL WEEKLY, *and published in* THE OIL WEEKLY *of November 17, Secretary Harold L. Ickes, Petroleum Coordinator, has answered the questions propounded him and in an earnest, straightforward manner, has set forth the "assignment of duty" for the industry, requested of him.*

The letter was received too late in the week to allow comment on it in this issue, but comment will be made on it in the December 22 issue. There is time available, however, for THE OIL WEEKLY *to say that the Petroleum Coordinator has given a very frank, and cooperative reply to a letter which set out questions current in the oil industry, and, to add that* THE OIL WEEKLY *accepts the assignment given it by the Petroleum Coordinator which assignment it will fill to the topmost limits of its ability.*

The letter from Coordinator Ickes follows:

December 9, 1941.

Mr. Ray L. Dudley, Publisher,
The Oil Weekly,
Houston, Texas.

My Dear Mr. Dudley:

It is a pleasure to answer your friendly and encouraging letter of November 12 in the same spirit in which it was written. I want you to know that as long as I am Petroleum Coordinator I will always welcome frank inquiries and helpful suggestions of the type contained in your letter. I want to thank you, too, for the pledge of cooperation by "The Oil Weekly." In return, I hope that you and the petroleum industry will always find the Office of the Petroleum Coordinator more than willing to meet you halfway in mutual cooperation.

The Industry's War Problem

The specific questions asked in your letter are of great importance to the petroleum industry and to those military and civilian consumers who depend upon oil. I know you will be interested to learn that the questions you ask were among the first that I asked of members of my staff, and placing ourselves in a position to answer those questions has occupied a large part of the time of this office and of the various petroleum industry committees. Your letter arrives while the data necessary to the answers are being assembled and I am glad at this time not only to agree with you that it is high time that these questions are answered, but also to offer preliminary answers to some of the questions.

As your letter suggests, I do know something about the difficulties of curtailing the non-defense use of petroleum products in such a way as not to impair civilian morale, and it is my earnest hope that the demands of this emergency will not increase to the point where the productive facilities of the petroleum industry might prove incapable of meeting both defense demands and civilian requirements.

A Survey of Present Productivity

You ask, "Isn't it high time to find out just how much additional oil can be produced without adversely affecting ultimate recovery, simply by 'opening the valves'? Isn't it time to find out where this oil can be produced?"

This is one of the questions that for months has been receiving the attention of my staff and the District Production Committees, and it is becoming clear that the extra productivity of this country is centered chiefly in those districts that have consistently practiced conservation. Those fields which have been giving their all in the interests of short-term pay outs and quick profits now have little to offer our defense program except requests for material and equipment with which to salvage part of the oil which their past practices have rendered difficult to produce when it is needed.

I am intensely and vitally interested in the quantity of oil that our oil fields can efficiently produce two years from now, after having produced at not less than those rates during the interim, rather than in what these fields can produce this month. We know where we stand. We can only guess what to expect. Consequently, each flush or semi-flush field must be operated so as to yield, under proper conservation practices, the full production which it can supply throughout the emergency. Otherwise, we would have to call upon the geologists and wildcatters for accomplishments which might prove impossible and, at the same time, require an excessive use of critical materials.

You realize, of course, that much of the unconcern with which the public and many officials view the plight of the petroleum industry in its clamor for materials and supplies is due to a widespread

HAROLD L. ICKES
"I sincerely believe that we are busy in a big way"

belief, industry-nurtured, that the petroleum industry could, without qualification, meet any possible demand upon it. Such are the fruits of the bountiful "potential" trees which have thrived vigorously in many states. Because the petroleum industry has been "oversold" to the public you will appreciate the desirability of a gradual rather than an abrupt correction, lest the reaction be as harmful as the action itself. For this reason, it is hoped that the regulatory bodies of the various oil producing states may review and modify, if not abandon, the use and application of the term "potential" in its present numerous fallacious connotations, most of which have no reasonable relation to the ultimate yield of a property or field.

Future Unpredictable—Must Be Ready

The most difficult question you ask is, "Isn't it time to present the industry with some concrete figures as to what will be expected of it in the way of daily production of crude oil—and to find out how much drilling will be necessary to do this and to place the crude reserves at a desirable figure?" This can be answered only by preliminary, tentative estimates which doubtless will have to be revised periodically.

The quantity of crude oil required by our own defense effort and by our world-wide obligations is unpredictable because of its dependence upon military successes and failures. The petroleum industry therefore must always remain "at the ready" to give its utmost. I need only remind you that the Bureau of Mines estimate of the December 1941 demand for crude oil is 4,139,000 barrels daily, a truly astounding figure, which is an increase of 17 percent over the December 1940 demand of 3,562,500 barrels daily. A similar percentage increase, should it occur, would bring December 1942 demand to a point which is beyond the capacity of our presently known oil fields to produce on a sustained efficient basis. Although your question did not include an inquiry as to whether we could transport and refine such a quantity of crude oil, that, too, is a very grave problem.

My expressed concern over the petroleum reserves of this Nation has been pointed toward a time when we will have exhausted our resources in advance of the rest of the world and, therefore, will have to depend upon costly substitutes or look to imports to fulfill our requirements. Although the time must inevitably come when year after year the production of crude oil will exceed the new reserves discovered, as is now the case with the depleted states of the Appalachian area, I do not believe that such a time has yet come for the United States as a whole. Every year in which our discoveries of oil are less than the amount produced finds our task of regaining position much more difficult. This task of maintaining known reserves at a desirable ratio to current annual rate of consumption now is doubly difficult because the more and more elusive reserves must be found in even greater volume to attempt a maintenance of the reserve-consumption ratio in the face of a skyrocketing increase in crude oil demand.

This task will continue long after the present emergency has passed. If our sustained productivity is allowed to diminish during this critical period, with our Nation now under dastardly attacks throughout the tremendous areas of the Pacific, we will have even more serious problems confronting us during the post-war reconstruction period. Then, as now, we will face the necessity of operating our fields at the rate of maximum efficiency while continuing to bring into sight additional reserves to meet equally important demands.

Drill to Maintain Output and Reserves

With respect to the volume of drilling probably required in the future no precise answer can be given. The recent rate of drilling activity approximates 30,000 wells annually and, if they continue to show the productivity witnessed in the recent past, that might suffice for both the necessary amount of daily production and the proving up of sufficient available reserves, although it is possible that 15,000 above-average wells would suffice, or, if below average, 45,000 wells might be necessary. We must remember, too, that 1942 drilling must also prove sufficient additional areas for 1943 drilling.

Use Available Supplies Efficiently

Your next question, "Then, when the amount of necessary drilling has been calculated, isn't it time to get busy in a big way and see to it that the industry has the necessary supplies with which to do the job?" enables me to say that I sincerely believe we are "busy in a big way" in helping the petroleum industry get the tools it needs to do the job. A considerable portion of the staff of this office is kept very busy in its duty of acting as an end product commodity section for the Office of Pro-

duction Management. Through the Materials Section of this office are cleared expeditiously and efficiently the multitude of applications for preference rating which require appraisal and recommendation by this office before consideration and action by the Office of Production Management. We have been engaged continuously in the task of improving and expediting this process, and we intend to keep at it.

In addition to this service to the petroleum industry, this office has specifically requested the Supply Priorities and Allocation Board to allot the petroleum industry 5,400,000 tons of steel and other materials to meet its needs for 1942. You will note that it is expected that oil will cost about seven pounds of steel per barrel in 1942. If less than the requested quantity of steel is allocated in 1942, the industry will nevertheless be expected to do all that is required of it. This will mean the drilling of fewer but better wells and the construction of fewer but more efficient pipe lines and refineries. In connection with our efforts to get the most oil for each pound of steel, we find that the most difficult part of the job is to make people realize that this emergency really affects them. Too many people in the oil business are still trying to conduct business as usual, particularly in the producing and refining divisions.

Increase Stocks in Ratio to Demand

The suggestion you offer when you ask, "Isn't it time to determine whether or not the crude stocks of the country are at their proper level—at their proper level at the proper points?" is now in the hands of the District Industry Committees for consideration and recommendation. Our preliminary studies, as well as the opinions of those who actually hold the petroleum stocks, have convinced us that aboveground stocks of petroleum, like underground reserves, are too low in proportion to current demand. These studies also make it apparent that different districts have different stock requirements as expressed in terms of "days supply." An early report is expected from the District Committees, and an announcement will be made immediately thereafter. In the meantime, you will note that the production which will result from the forecast of December demand will likely interrupt the steady shrinkage of present stocks. In this connection it is evident that although the consumed stocks may have come from many states, only a few states will be able to assist in replenishing those stocks.

Unnecessary Wells Biggest Waste

As your last question you propound, "If there is physical waste in the oil industry which can be cured during this emergency, why not tell the industry specifically where such waste is occurring?" You know, as I do, that whenever an unnecessary well is drilled, an unnecessary pipe line or refinery constructed, there is actual physical waste of the irrecoverable materials that go into such drilling or such construction. Unnecessary wells are perhaps the worst offenders, because, as experience has amply demonstrated time and again, in addition to the amount of steel that is permanently lost when casing is cemented in such wells, their existence almost inevitably leads to inefficient operation of fields at excessive rates of production, with attendant underground loss of recoverable oil. I realize, also, that the waste of a commodity is frequently inversely proportional to its value, which fact may account for the continuing waste of large volumes of natural gas in some areas, the value of which for increasing oil recovery may not yet be fully appreciated.

I am glad to note that during the past ten years the actual physical waste of oil resulting from inefficient development and production operations has declined steadily as the industry in general, but with some notable exceptions, has become more aware of its responsibilities. Although possibly not actually permanently lost or destroyed, the quantities of oil that inefficient production practices are continuing to leave underground in several states and areas must be considered lost or wasted, until much higher prices for petroleum warrant the application of expensive secondary recovery methods.

The Industry's Assignment

You ask for an assignment for the petroleum industry. I have indicated the scope of such an assignment in the foregoing paragraphs, but to recapitulate, here is what is expected of the petroleum industry:

1. **Produce at least 1,500,000,000 barrels of crude oil during 1942, if that quantity can be supplied without impairing the ability to sustain the necessary production during the emergency.**
2. **Drill a sufficient number of wells, efficiently spaced, to furnish that amount of oil next year and to prove up sufficient reserves to furnish at least that amount during the following year.**
3. **Operate all wells so as to conserve reservoir pressure to the end that the greatest practicable ultimate recovery will be attained at the lowest possible cost, with minimum expenditures required to provide artificial energy to effect production.**
4. **Conduct an exploration campaign that will result in the discovery of new supplies adequate to maintain a comfortable ratio between reserves and current annual consumption.**
5. **Maintain surface stocks of crude oil at adequate levels with respect to refinery requirements for the various grades and qualities of products as well as stocks of the products sufficient to protect against any unusual demand that may arise.**
6. **Make the most efficient use possible of the limited supplies of material and equipment to meet the demand upon all branches of the industry, finding, producing, refining, transporting and marketing.**

I want to thank you again for your concise letter, raising such important questions. I hope that you find my answers helpful and indicative of the extensive studies which we have been prosecuting for months, with the able assistance of the experienced oil men now serving on our District Committees for National Defense. And now may I look to you, and other members of the petroleum press, to keep your readers fully informed of our activities so that we may have their cooperation and support as well as yours?

Sincerely yours,

(SIGNED) HAROLD L. ICKES,
Petroleum Coordinator for National Defense.

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EDITORIAL INDEX, PAGE 1

ADVERTISERS' INDEX, LAST PAGE

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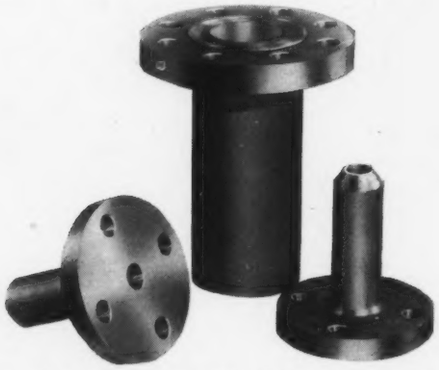

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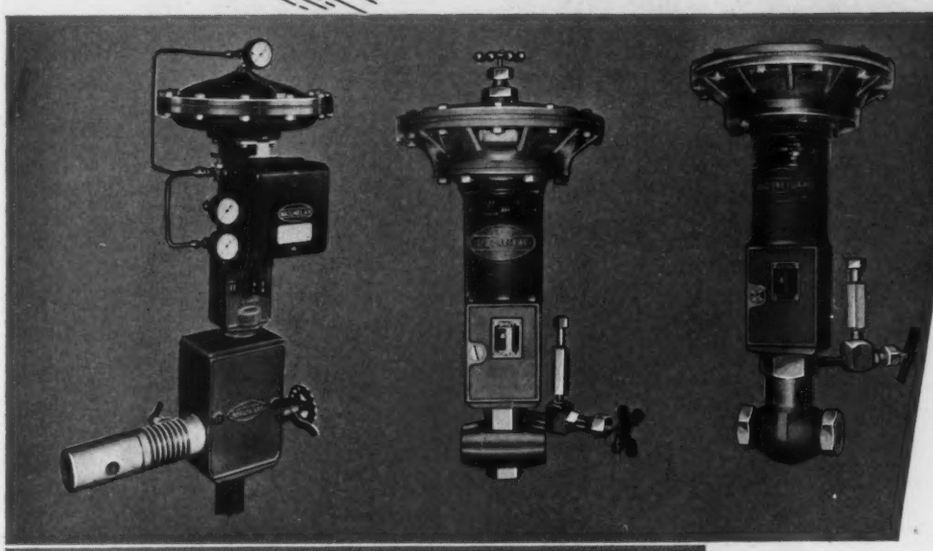

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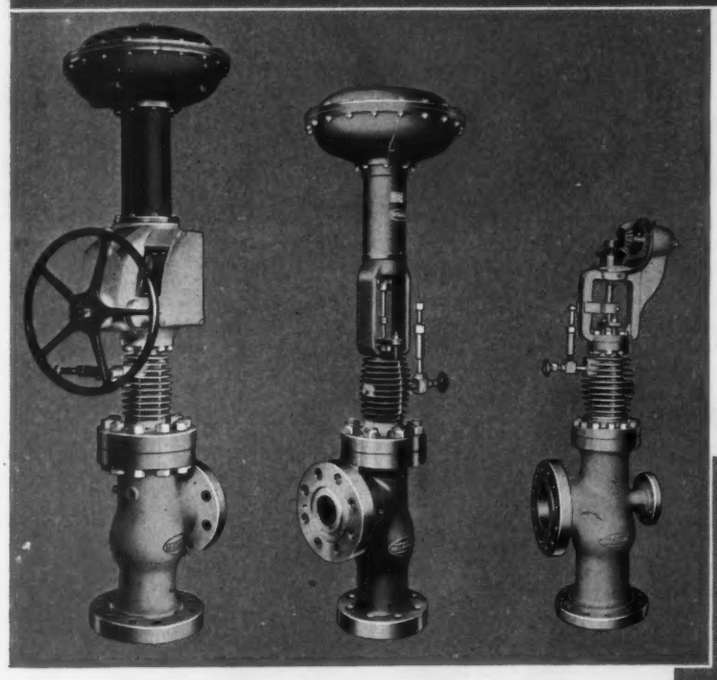
Handling drops instead of barrels at pressure drops from ounces to 6,000 lbs. With trim designed specifically for each individual application. These shown are a few of the many types that have been built.



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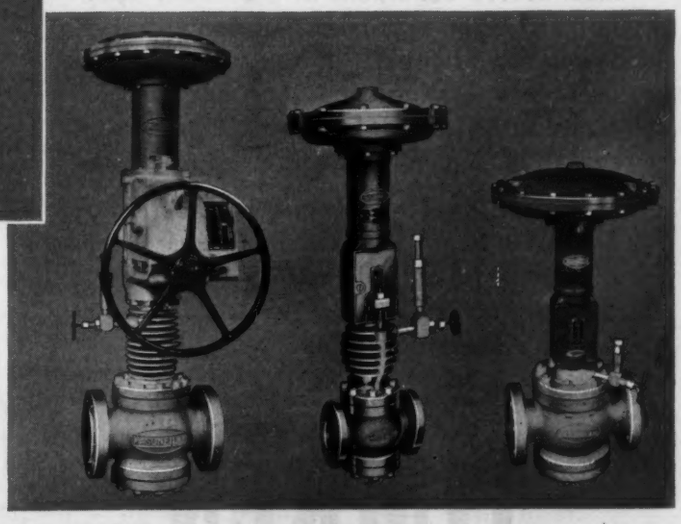

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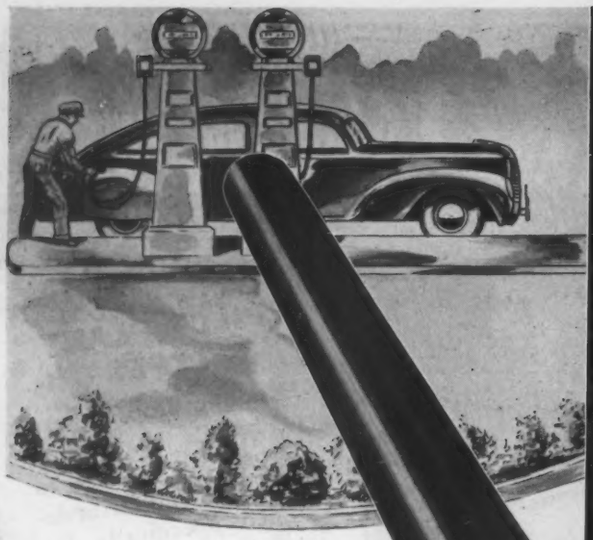
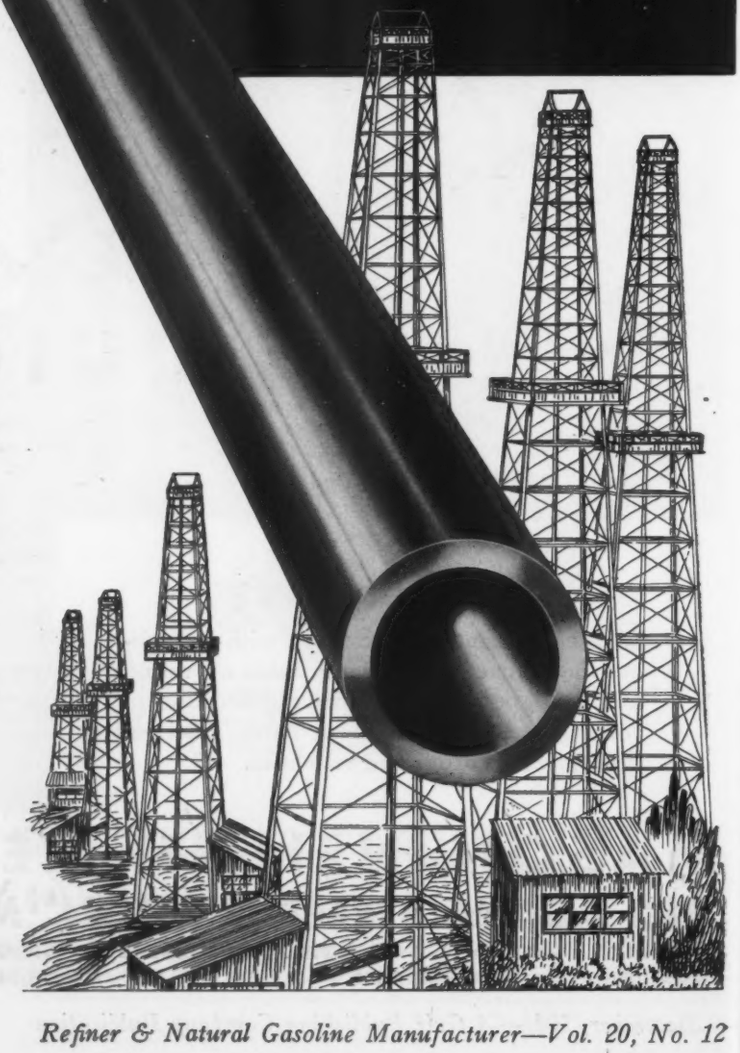


BETWEEN OIL WELL AND GAS TANK



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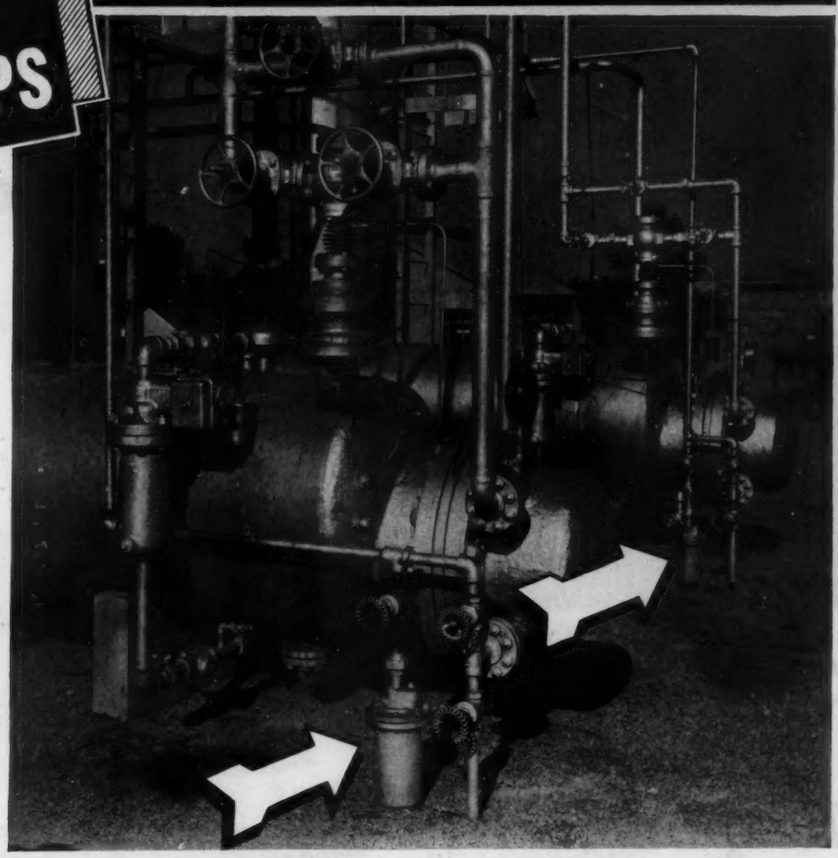

The arrows point to two Armstrong Traps on reboilers in natural gasoline plant in Arkansas. Handy engineering data on heat transfer rates is printed in the new Armstrong Steam Trap Book—ASK FOR A COPY.

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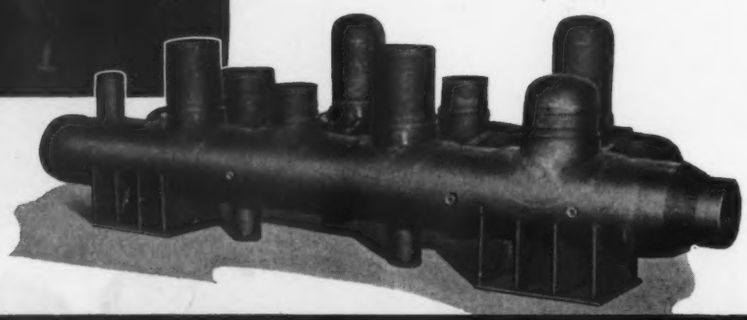

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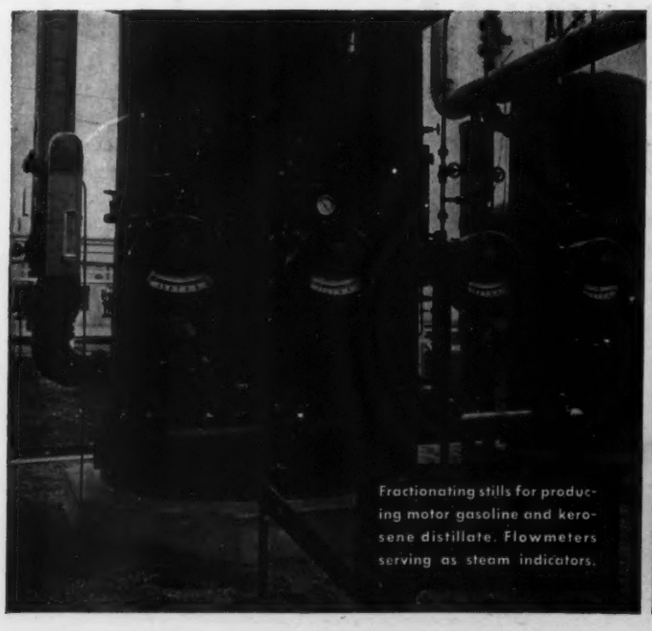
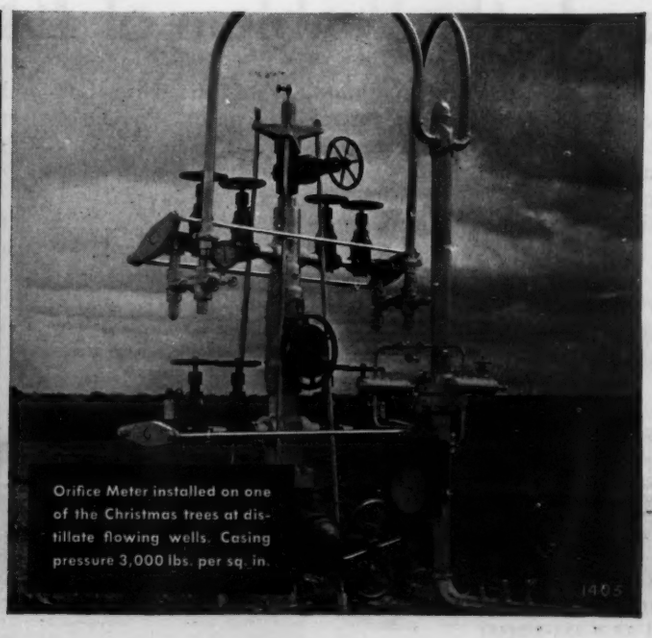
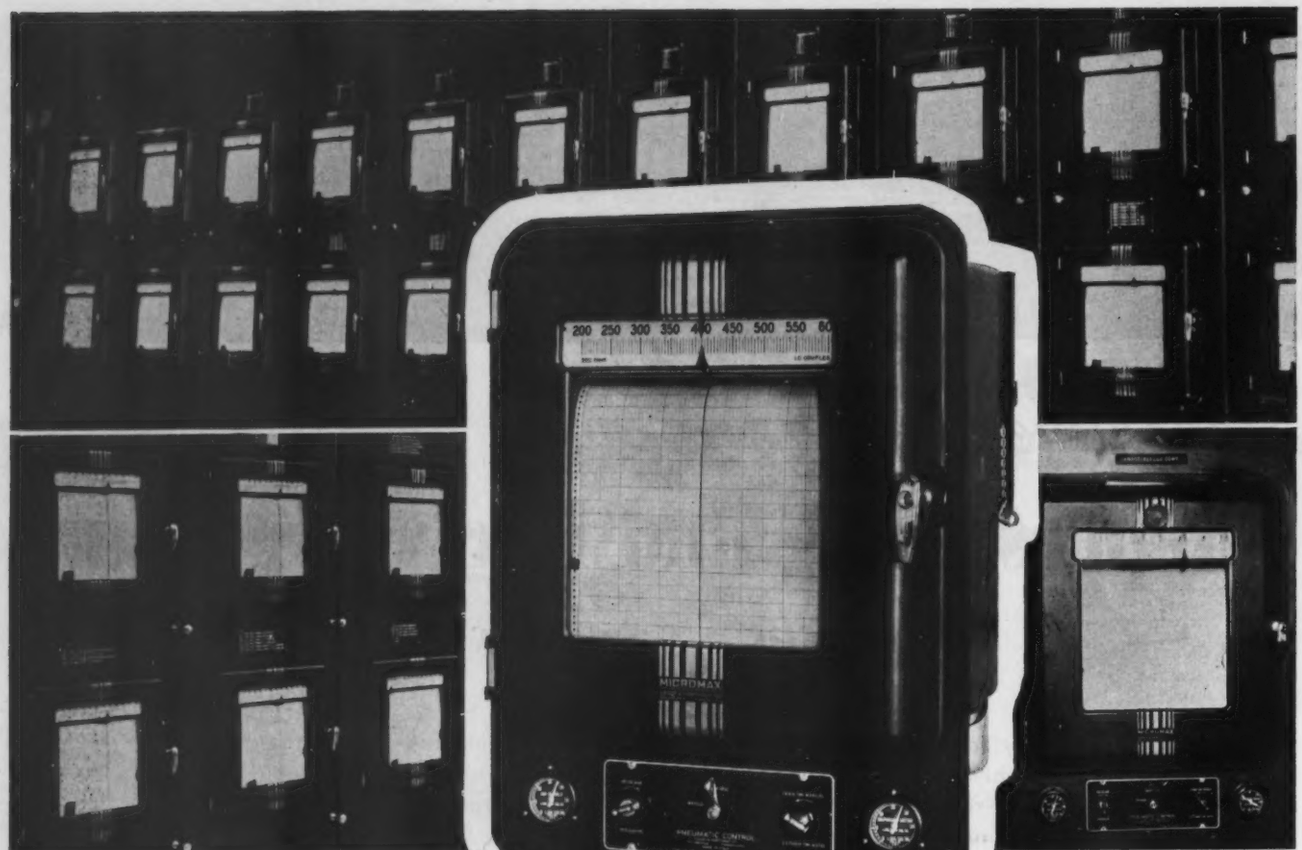


Fractionating stills for producing motor gasoline and kerosene distillate. Flowmeters serving as steam indicators.



Orifice Meter installed on one of the Christmas trees at distillate flowing wells. Casing pressure 3,000 lbs. per sq. in.



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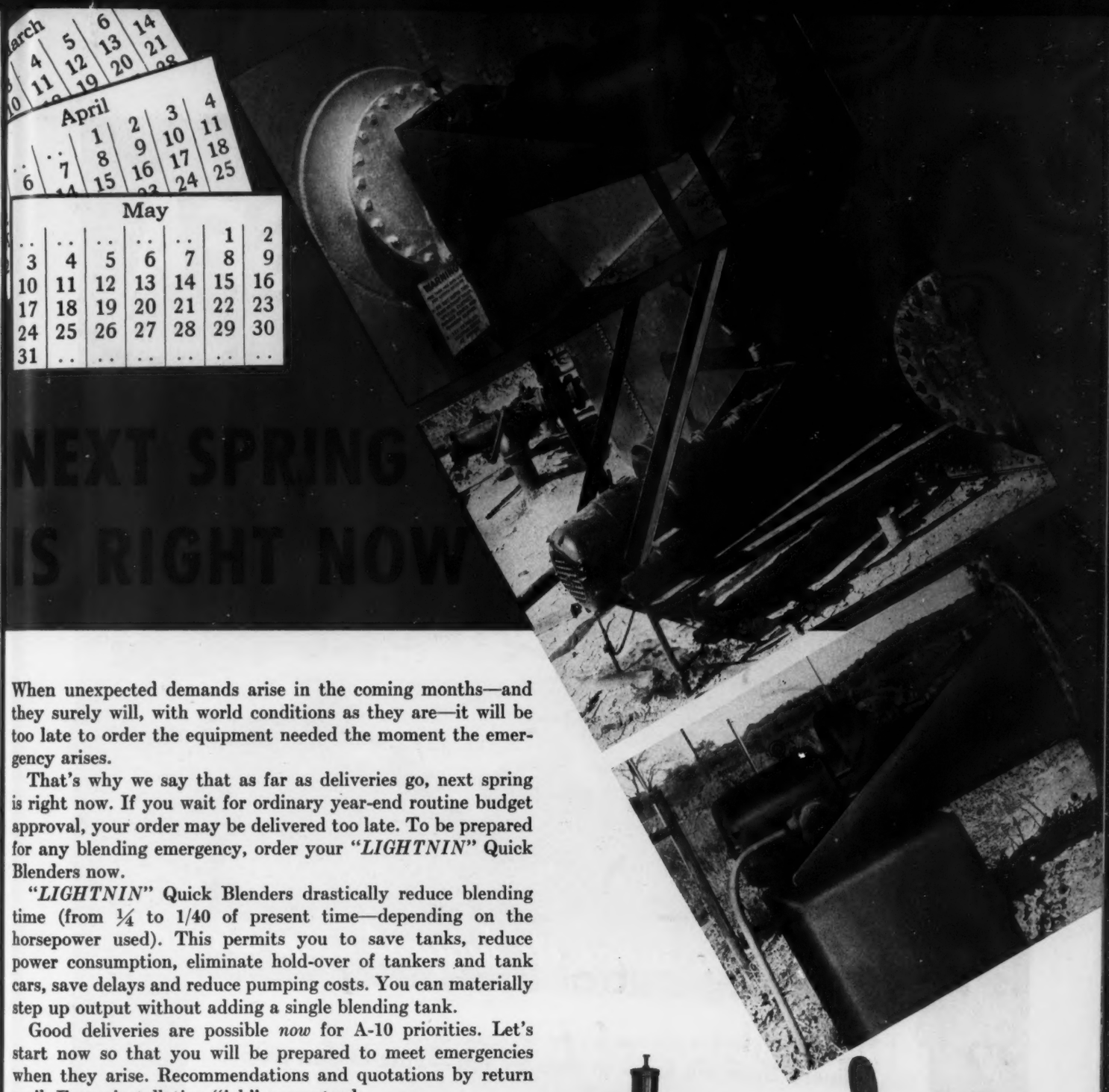

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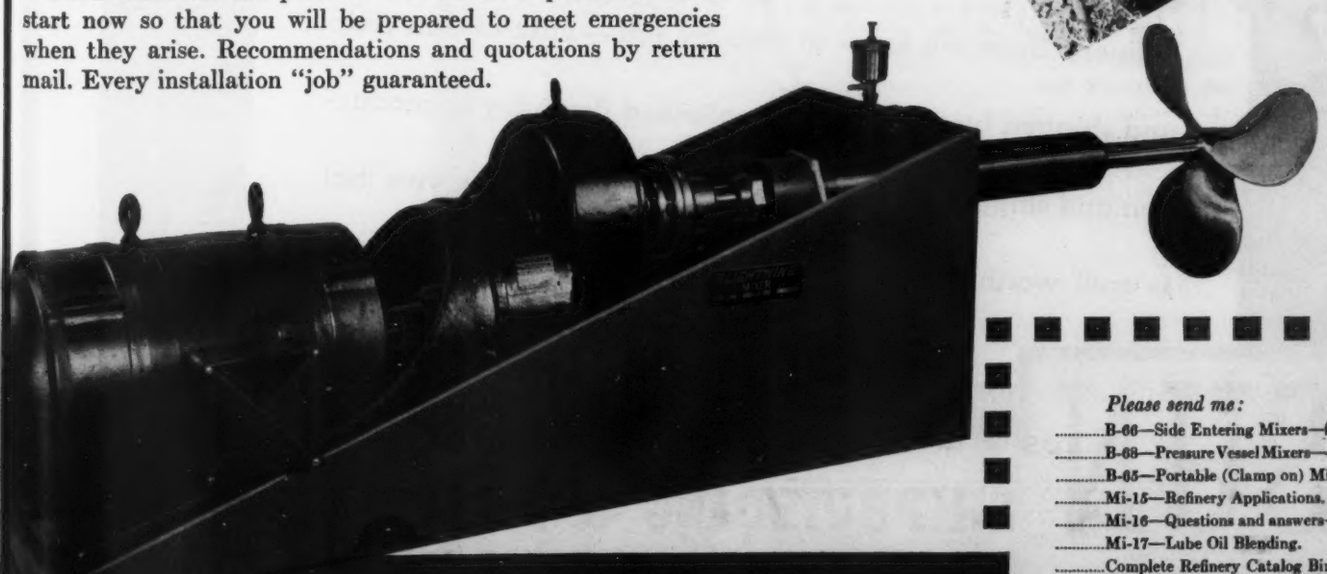

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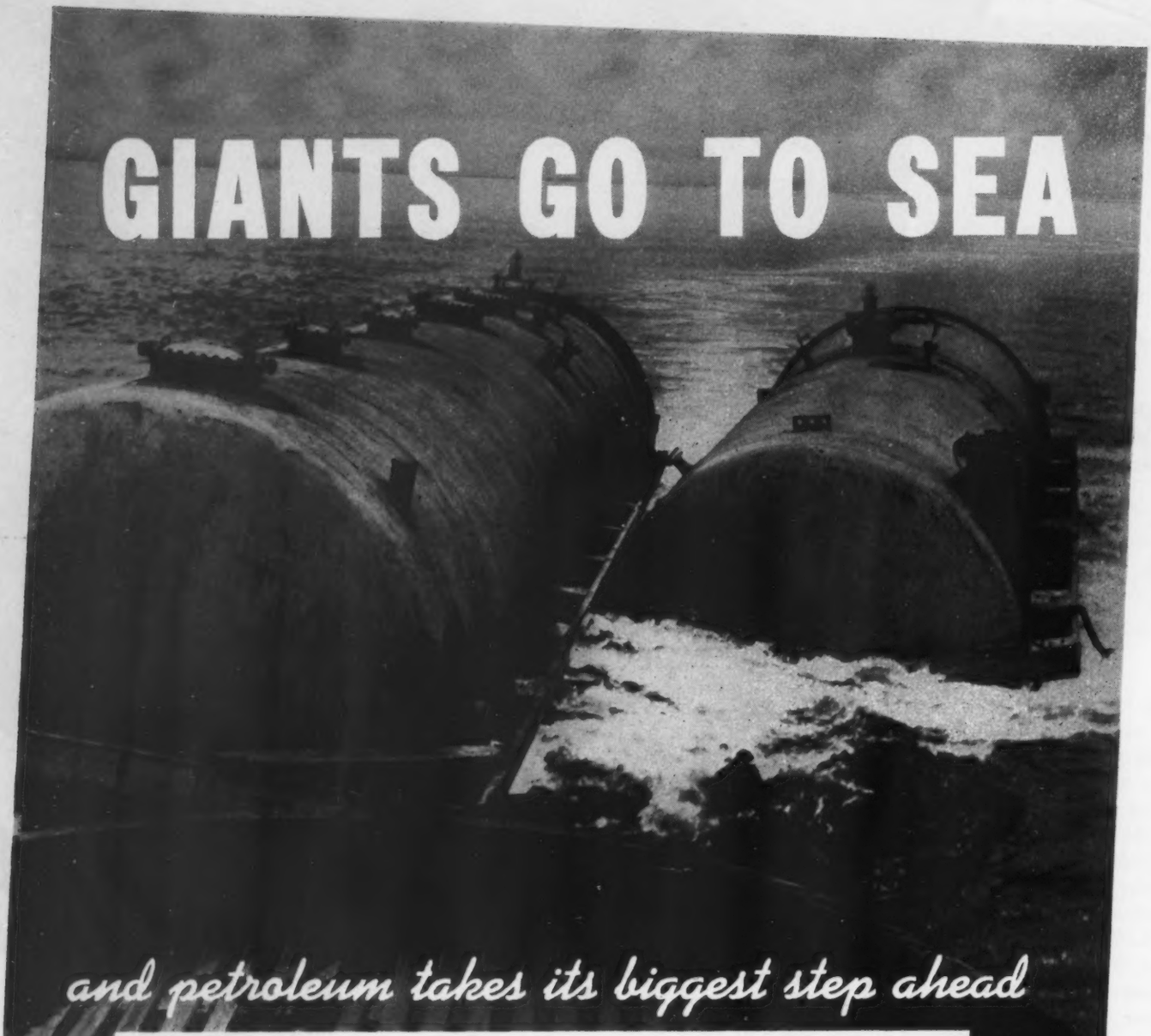

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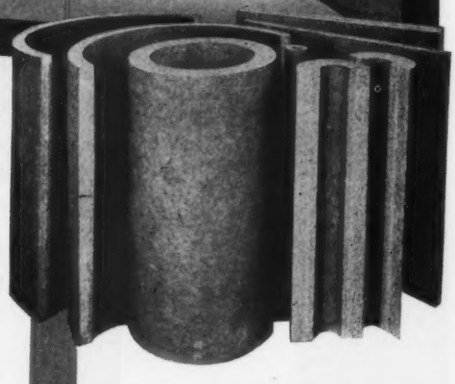

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WHENEVER **PIPING** IS INVOLVED

What Types of Corrosion Affect Condenser Tubes?

A second report by Scovill engineers, analyzing the major types of corrosion that shorten condenser tube life

In our last report on tube corrosion, which recently appeared in this space, the five factors which singly or in combination underlie all corrosion were discussed. They are: acidity, temperature, dissolved oxygen, velocity, and electro-chemical action. The corrosion resulting from these factors is frequently complex and not always accurately predictable, but a study of our case records indicates that seven general types account for the major share of the difficulties reported.

These seven are worthy of study, as they set up an experience table against which your installation can be studied and compared.

Dezincification

Dezincification of brasses is the result of an electro-chemical action in which the metal as a whole is dissolved and the copper in solution is redeposited at the point or zone of attack. It results in the formation of layers or plugs of copper which generally are porous and brittle. Once started, this condition often progresses until the porous copper deposit penetrates the tube wall and leaks result.

The tendency of brasses to dezincify varies with the zinc content, those alloys containing less than 15% zinc being relatively immune.

Factors known to favor this type of corrosion are:

1. High operating temperatures.
2. Brackish, acid, and other contaminated circulating waters.
3. Sluggish or stagnant circulating water.
4. Certain types of permeable scale formations.
5. The composition of the alloy itself.

Deposit Attack, General Pitting and Other Forms of Intense Localized Attack

If a foreign material is deposited on the tube wall, an electro-chemically active cell may form, since in connection with the deposited foreign matter the opportunity for the formation of either an oxygen-concentration cell or a solution-concentration cell is present and likely to cause a rapid and intensive local pitting of the tube wall. A similar action may be initiated in other ways, as for example, a discontinuous coating of scale or corrosion product on the metal surface, surface defects, etc., resulting in general pitting, or an intense local pitting. This form of attack is probably the hardest to combat, since the electro-chemically active cells will corrode any known heat exchanger tube material, although some materials are less subject to such action than others.

General and Uniform Solution of Material

Tubes sometimes dissolve uniformly over their entire surface. Such solution is commonly the result of circulating media which are acid in nature. If the action proceeds rapidly, the choice of material has undoubtedly been unwise, and a change to a new alloy can ordinarily be made to effect a decided improvement in service life.

Galvanic Action

The normal use of copper alloys in heat exchanger equipment is such that galvanic action does not ordinarily play an important part in their corrosion. While Scovill Service Engineers always consider the

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SERVICE IN MANUALS . . .

possibilities of galvanic action, the ordinary materials of construction, namely, steel shells and tube sheets in connection with copper base alloy tubes, do not cause serious trouble of a galvanic nature. Where possible, we recommend copper zinc alloys for tube sheets, but in general do not insist upon their use.

Impingement Attack

This form of corrosion is a combination mechanical-electro-chemical one. The continual bombardment of tube walls by entrained gas bubbles, bubbles of gas released from solution by turbulence, or other foreign matter carried in the circulating medium results in the continual wearing away of the protective scale or film, leaving clean metal surfaces exposed to the corroding action of the circulating medium.

Such action normally confines itself to the inlet end of the tubes, although sometimes conditions are so bad that the tube is worn away throughout a major part of its length.

This form of corrosion is not common in petroleum exchangers but is frequently encountered in surface condensers circulating water at relatively high velocities. Mechanical changes in the circulating system designed to eliminate or minimize turbulence, entrained air, or other erosive materials frequently can be made to reduce this type of destructive attack. Sometimes it is necessary to change the tube alloy. Cavitation is closely related to impingement in that its action proceeds along erosive-corrosive lines. The action is associated with obstructions causing local turbulence, the release of dissolved gases in low-pressure areas adjacent to the obstruction, and a local bombardment of the tube wall.

Season Cracking and Stress-Corrosion

Season cracking is the failure of metal in repose, under no outside strain, and is the result of unbalanced internal stress usually associated with severe cold working. Alloys of high zinc content are more readily affected than high copper alloys. Very mild surface corrosion, particularly by ammonia or ammonium compounds, is a contributing factor to this type of failure.

Brasses containing over 85% copper are not generally subject to season cracking except under very severe conditions.

Stress-corrosion cracking is closely related to season cracking differing only in that stress is externally applied rather than existing as internal strains in the metal. Stress-corrosion cracking, therefore, is generally understood to mean the cracking of brass, initially free from internal stress, by the application of tensile stress and simultaneous attack by certain corrosive agents, particularly by ammonia or ammonium compounds.

Since the use of ammonia as a neutralizing agent is quite common, careful control should be maintained, since any excess contacting the copper alloy tubes may greatly reduce service life. Where possible, the substitution of sodium hydroxide or lime is recommended.

Corrosion Fatigue

If any of the aforementioned forms of corrosion are accompanied by vibration or other alternate mechanical stressing, a premature fatigue failure is likely to result, since the endurance limit of metals is materially reduced by corrosion.

Scovill Offers 3 Services to Condenser Tube Users

SERVICE IN MANUALS. If you are interested in further information on Condenser and Heat Exchanger Tubes, the relative resistance to corrosion of metals and alloys commonly used in this service, and similar technical material, send for a copy of the Scovill booklet "Condenser Tubes." Its 67 pages contain a summary of technical information which many users of Condenser and Heat Exchanger Tubes have found useful. A copy will be sent free upon request to Scovill Manufacturing Co., 15 Mill St., Waterbury, Conn.

SERVICE IN MEN. An experienced staff of service engineers is available to study your particular problem and offer the practical benefit of their advice.

SERVICE IN METALS. Experimental furnaces and research laboratories are maintained, not only for development work, but also for testing and selecting proper metals for your specific requirements.

Scovill, for many years a regular source of supply for the U.S. Government, is cooperating in every way to forward defense plans. When deliveries are not as prompt as our customers desire, we hope they will realize that delays are sometimes unavoidable and part of the price paid for national defense.

Condenser Tubes

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SERVICE IN METALS . . . SERVICE IN MEN

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This is a catalytically active material when used alone or as a catalyst support. The pores occupy 50% of the particle volume.

Hydrated Alumina C-730

An Alumina which is active after an original heating to 500°F. It has finer particles and greater surface area than obtainable with ground natural minerals.

Inactive Types

Tabular Alumina

This Alumina is a substantially inactive catalyst carrier. Close mesh sizes are obtainable.

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You may be able to simplify and speed up your catalytic reactions, boost their efficiency, increase their yield, with one of the Aluminas.

Aluminas serve in three ways; as catalysts, as carriers, and as carriers and auxiliary catalysts. Because Aluminas are pure, there is less likelihood of uncontrolled side reactions and poisoning. Some forms are soluble in either acids or alkalies, making it easy to recover expensive catalysts.

A most important generalization is that Aluminas help prevent the formation of free carbon. Less free carbon means less clogging of the pores, more favorable conversions and yields.

The physical properties of Aluminas suit them for long use with a minimum loss of productive capacity. The greater surface area of the Aluminas increases the efficiency of the catalysts.

For samples to test in your processes, write ALUMINUM COMPANY OF AMERICA (*Sales Agent* for ALUMINUM ORE COMPANY) 1963 Gulf Building, Pittsburgh, Pennsylvania.

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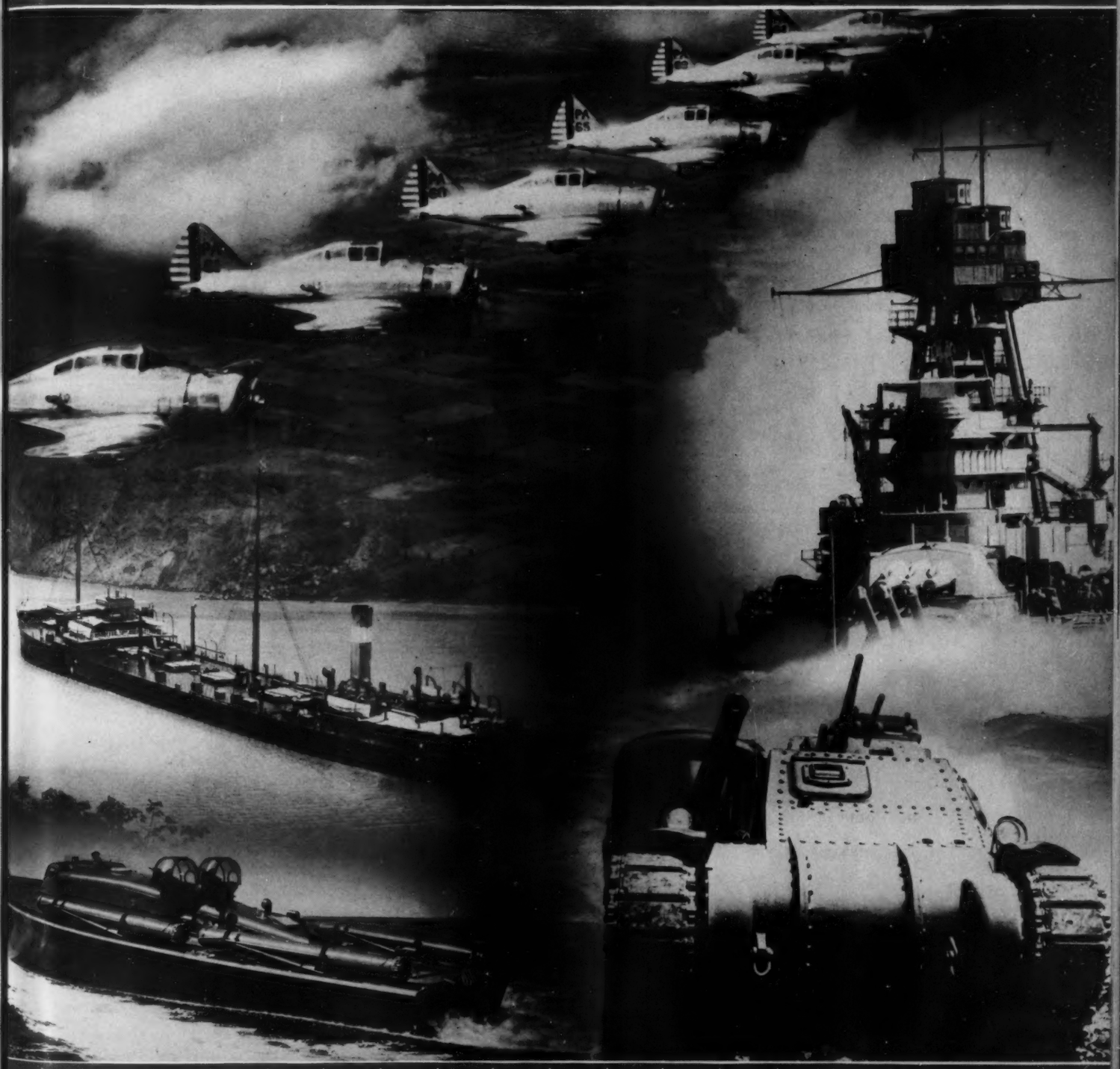
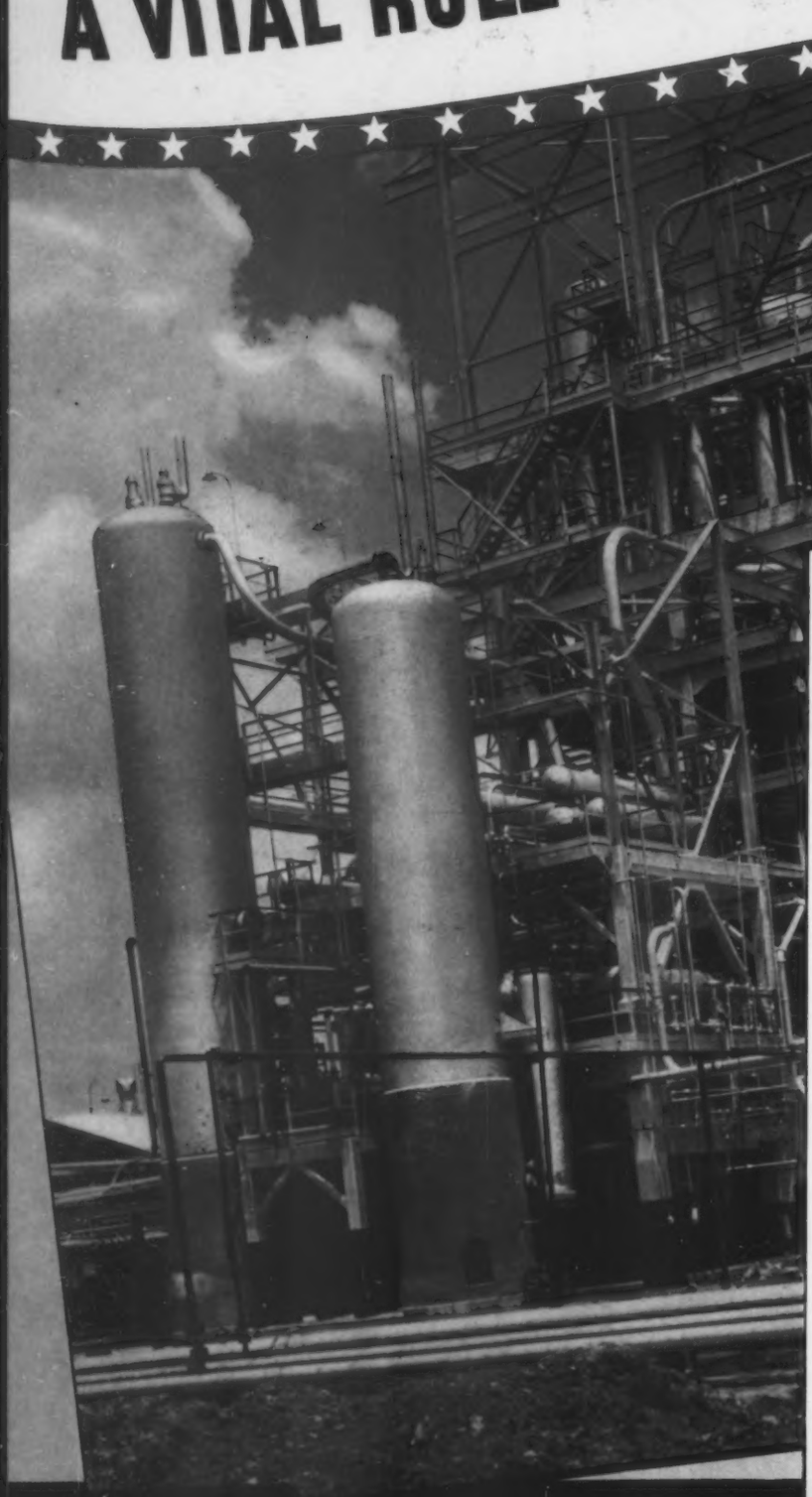


PHENOL... AMMONIUM PICRATE

A VITAL ROLE IN NATIONAL DEFENSE



Cooperating with the petroleum industry and the government in the national defense program, Lummus is now building:

- ★ Complete plants for the production of 100 Octane Gasoline
- ★ Naphtha Polyform units for the preparation of butylenes for iso-octane plants
- ★ Iso-pentane, iso-butane, butylene and other 100 octane stock preparation units
- ★ Plants for the production of 91 Octane aviation fuel
- ★ Lube oil solvent plants for the production of specification aviation lubricating oils
- ★ Ammonium picrate plant
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This partial list of current construction is in addition to aviation gasoline and other plants completed by Lummus since the inception of the national defense program.

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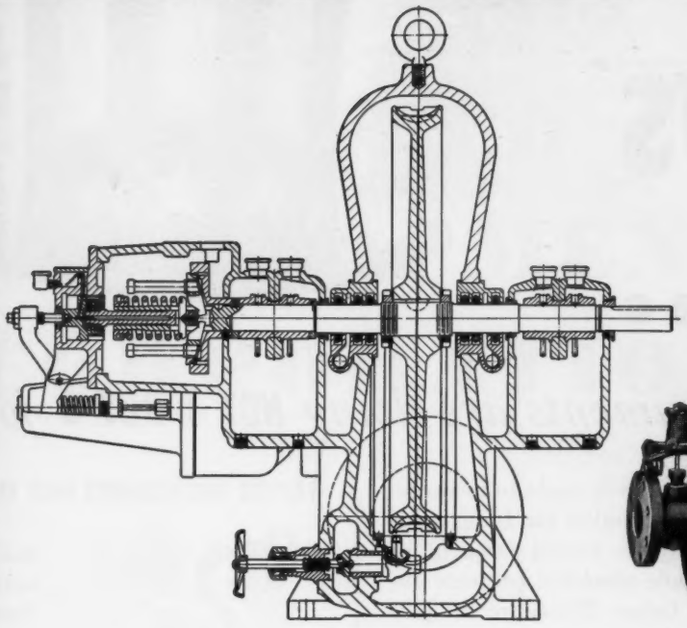
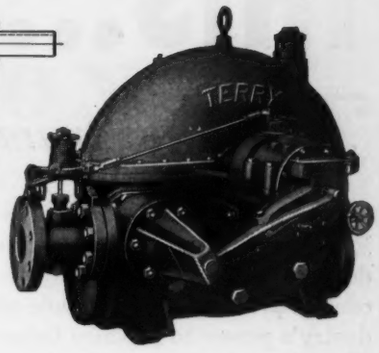
PETROLEUM REFINING PLANTS

TERRY





For Year After Year Service — The Terry Solid Wheel Turbine

The Terry Solid Wheel Turbine employs a one piece steel wheel. The buckets are milled from the solid metal. There are no parts to become loose or to work out.

The blades have large clearances and are double rim protected. End play cannot damage the blading and it is impossible for it to foul.

The power producing action of the steam in the wheel takes place on the curved surfaces at the back of the buckets and therefore close blade clearance is not necessary.

Terry Solid Wheel Turbines are available in ratings from 5 HP to 2000 HP and are built for all commercial steam pressure and exhaust pressures. They are described in our bulletin S-116. A request on your business letterhead will bring a copy.

Above: Cross section of typical Terry Solid Wheel Turbine.

T-1141

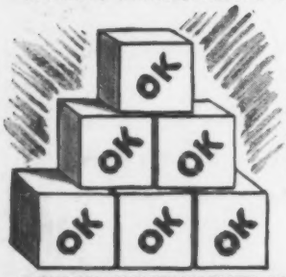
THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

UNCLE SAM KNOWS THIS...

Taylor Instruments are doing NOT 1 BUT 5 *jobs for defense*

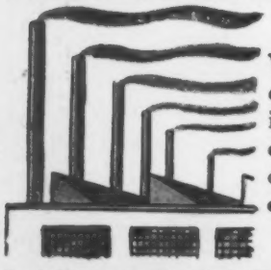
▶ Everything that Taylor makes is made to measure. Every instrument that Taylor makes for Industry is designed to indicate *precisely*, or record *precisely*, or control *precisely*. Taylor-made precision protects Industry's power to produce today. These are the jobs —*not 1 but 5 jobs*—that Taylor Instruments are doing for defense:

TAYLOR INSTRUMENTS HELP MAKE BETTER PRODUCTS



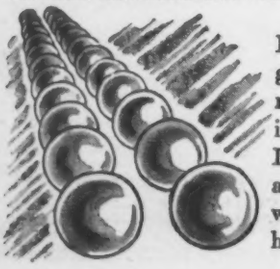
Constant top-grade perfection comes from using Taylor Instruments, because they permit complicated processing operations to be carried on automatically.

TAYLOR INSTRUMENTS HELP SPEED UP PRODUCTION



With Taylor Instruments on guard over industrial operations, insuring automatic precision, products can be turned out faster. Mishaps due to human errors get far less chance to gum up the works.

TAYLOR INSTRUMENTS HELP INSURE UNIFORMITY

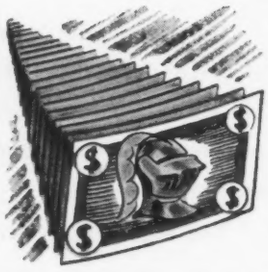


Exact duplication of operations, guaranteeing exact duplication of mass-made products, can be indefinitely carried on if Taylor Instruments are used to record and control those operations with the automatic exactness that human skill can't match.

TAYLOR INSTRUMENTS HELP FREE MANPOWER

Skilled employees in a Taylor-equipped plant do much less "sentry duty" merely watching over operations. They are freed for other more essential work. Taylor Instruments are automatic industrial sentries.

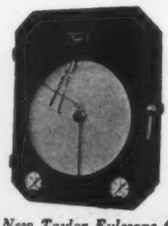
TAYLOR INSTRUMENTS HELP MAKE DEFENSE DOLLARS GO FARTHER.



Uncle Sam is likely to get more of the best for his money from plants using Taylor Instruments. Why? Because, by using Taylor Instruments, these producers often can cut their production, maintenance, and labor costs noticeably and can sell to the Government at lower prices without cutting profits!

Taylor Instruments should be doing these five—not one but five—jobs for you, too. We want you to be getting 100% satisfaction from your present Taylor Instruments, and we're here to see that you do. Perhaps we can suggest ways to improve your instrument performance. We've had plenty of experience in this industrial instrument business. How can we help you most? Taylor Instrument Companies, Rochester, N. Y. Plant also in Toronto, Canada.

Taylor-MADE MEANS BETTER MADE IN AMERICA BY AMERICANS



The New Taylor Fulscope Controller protecting America's power to produce with **not 1 but 5** *forms of control.*

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Indicating — Recording Controlling

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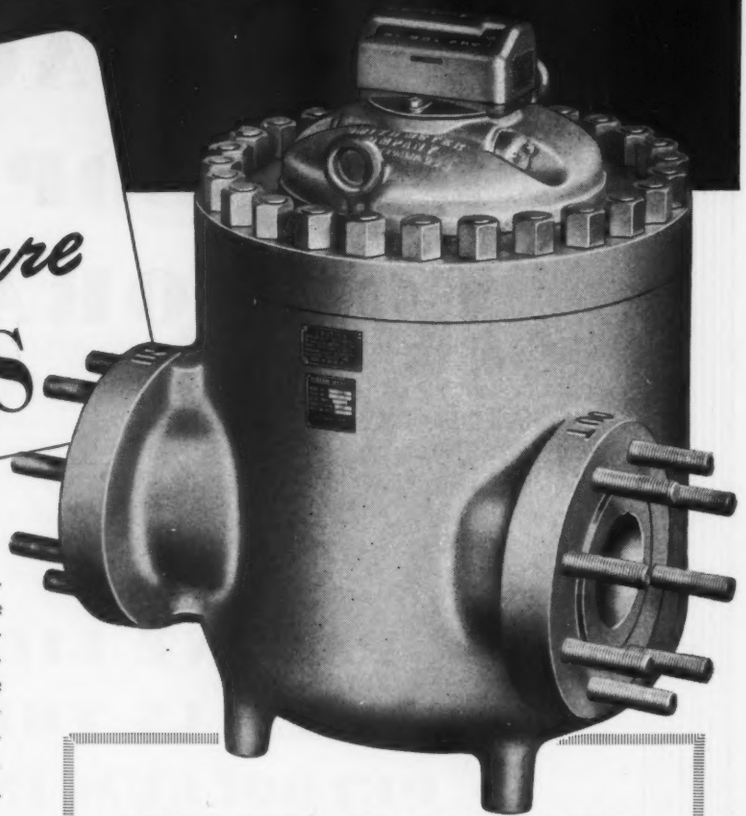
STREAMLINED FLOW
at Balanced Pressure!

SMITH *High-Pressure* METERS



LONG felt has been the need in pipe line and refinery service for accurate meters that assure continuous flow without distortion due to pressure changes or pipe line strains. Smith High-Pressure Meters—designed as they are on the original Smith rotary-positive displacement principle—adequately meet this need by providing vibrationless, *streamlined* flow at *balanced* pressure.

Pressure inside and outside the metering mechanism is constantly equalized to eliminate distortion of the measuring chamber . . . assuring greater speed and accuracy over wide ranges of flow, regardless of pressure fluctuations. Self-contained metering mechanism—mounted in a high-pressure steel housing—can be readily removed for inspection or cleaning without disturbing counter or pipe line connection. No valves! No pistons! No heavy reciprocating parts! Frictional resistance is practically eliminated. Conservative rotor speeds assure long life.

For complete details on Smith Meters for any petroleum need, write the nearest Smith office.

SMITH HIGH-PRESSURE METER
MODEL M-65

Capacity: 650 gals. per min., 929 bbls. per hour.
Working Pressure: 1000 lbs. Nickel steel housing.

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Special equipment available includes: Automatic Temperature Correction, Remote Reading Register, Rate of Flow Indication, and Special Alloy Construction to meet corrosive conditions.

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Smith High-Pressure Meters are made in three pressure ranges: 1000, 500, and 250 p. s. i., and in six sizes from 57 to 929 bbls. per hour.
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Extra Endurance

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● Making *more* replacement parts available by high priority ratings is one way to keep refining output at its peak. But—Republic Upson Stud Bolts do the job a better way. They give you better bolts with extra endurance to reduce the frequency of replacements.

Republic Upson Quality Stud Bolts resist punishing temperatures, high working pressures and severe corrosion attacks. They take heavy wrenching without breakage or slippage. They turn up to a tight grip quickly—and hold it. All because of their toughness all the way through; clean, strong threads; sharp-cornered nuts; accuracy to size; uniform fit.

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The Shell Isomerization Process economically converts normal butane to isobutane for aviation gasoline.

- *Simple plant.*
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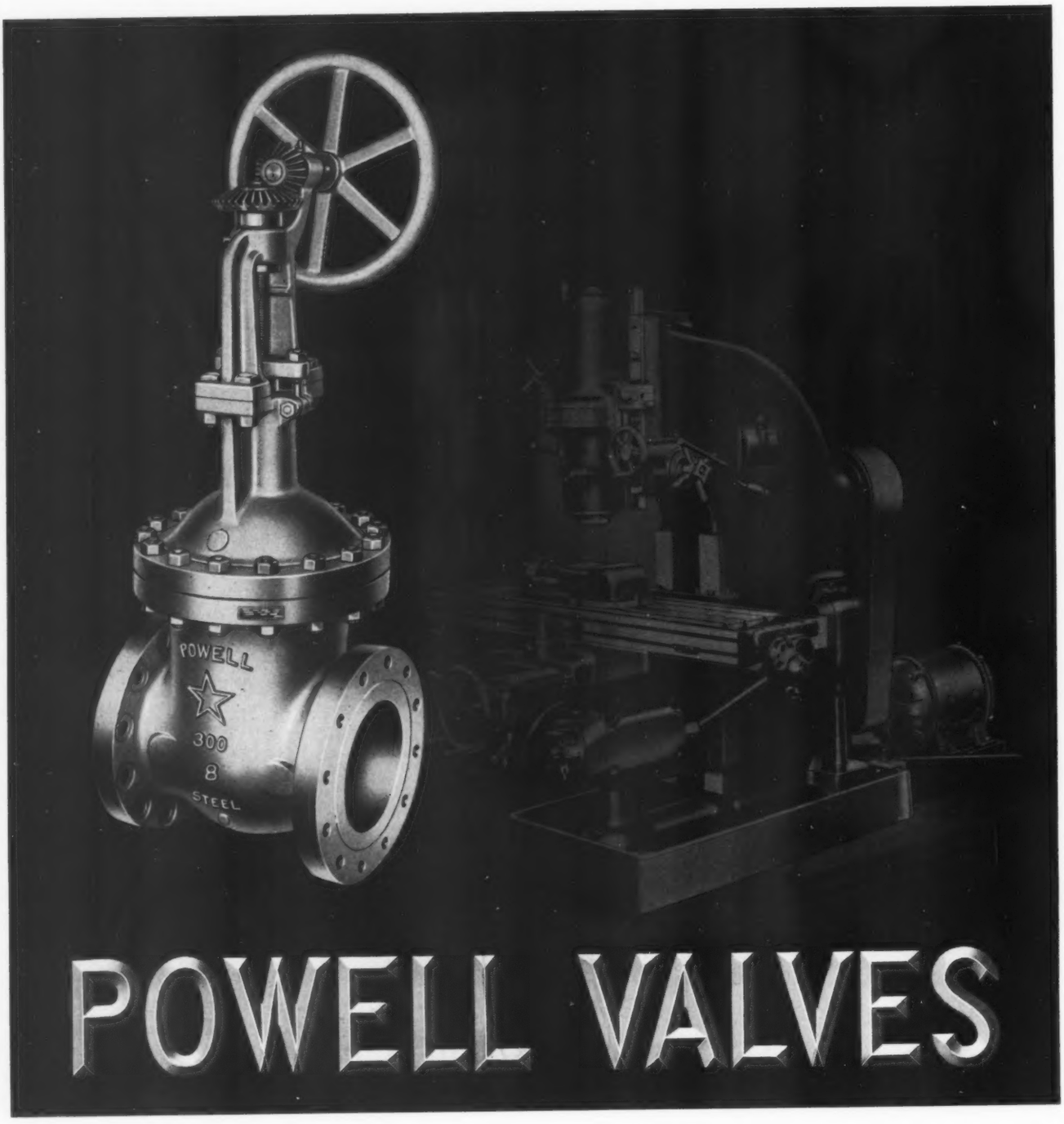

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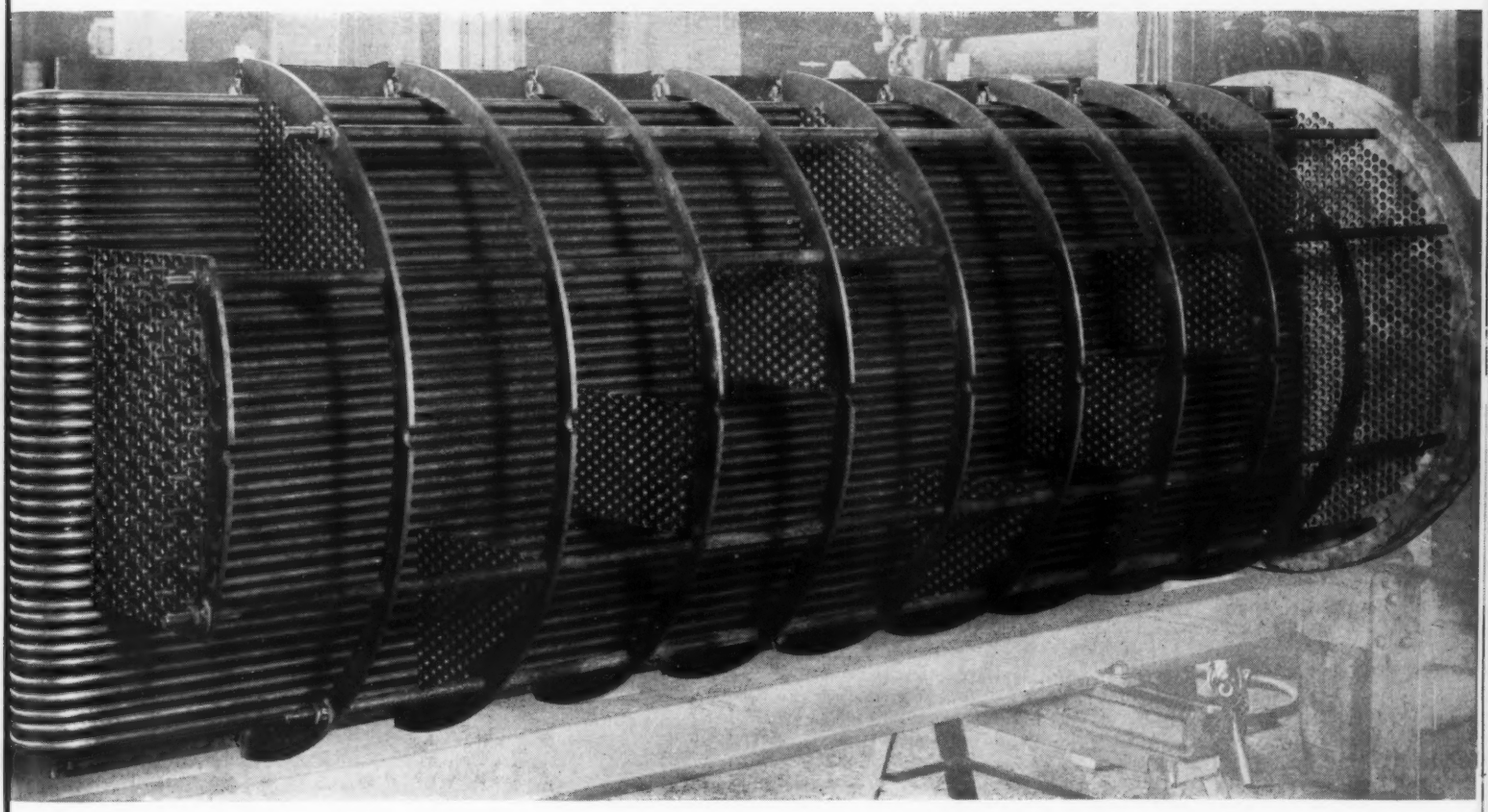
Shown here is an 8" class 300 lb. Cast Steel Gate Valve. It is furnished with standard faced or with R.T.J. flanges. Bevel gear operation on larger sizes. Especially designed to meet the special requirements of the Oil Industry it conforms in all respects to A.P.I. Specifications 600A—1939 and B-16E—1940. A fine example of Powell Engineering.

The Wm. Powell Company
Cincinnati, Ohio

It's not the first cost

—it's the Upcreep!



When tubes in heat exchangers, evaporators and condensers begin to fail—when frequent replacement becomes necessary—it's the rising cost of maintenance and replacement plus the cost of lost operating time—the *UPCREEP* of expense—that eats into profits.

And when these costs start to creep up and up—when the tubes you are using lack the ability to resist the attack of corrosion and high temperatures — it's time to change to longer-lasting tubes.

In most types of severe service, Republic ELECTRUNITE Stainless Steel Tubing—made of Republic's time-proved ENDURO*—will substantially retard the upcreep of maintenance cost. Yes, it costs more than carbon steel tubing—but the savings may be many times the extra cost.

Republic ELECTRUNITE Stainless Steel Tubing affords all the advantages of the electric resistance welding process, too—including consistent uniformity, strength, scale-free surface and ease of fabrication. Write for the complete story. Steel and Tubes Division, Republic Steel Corporation, Cleveland, Ohio.

REPUBLIC STEEL — DEFENSE FOR AMERICA

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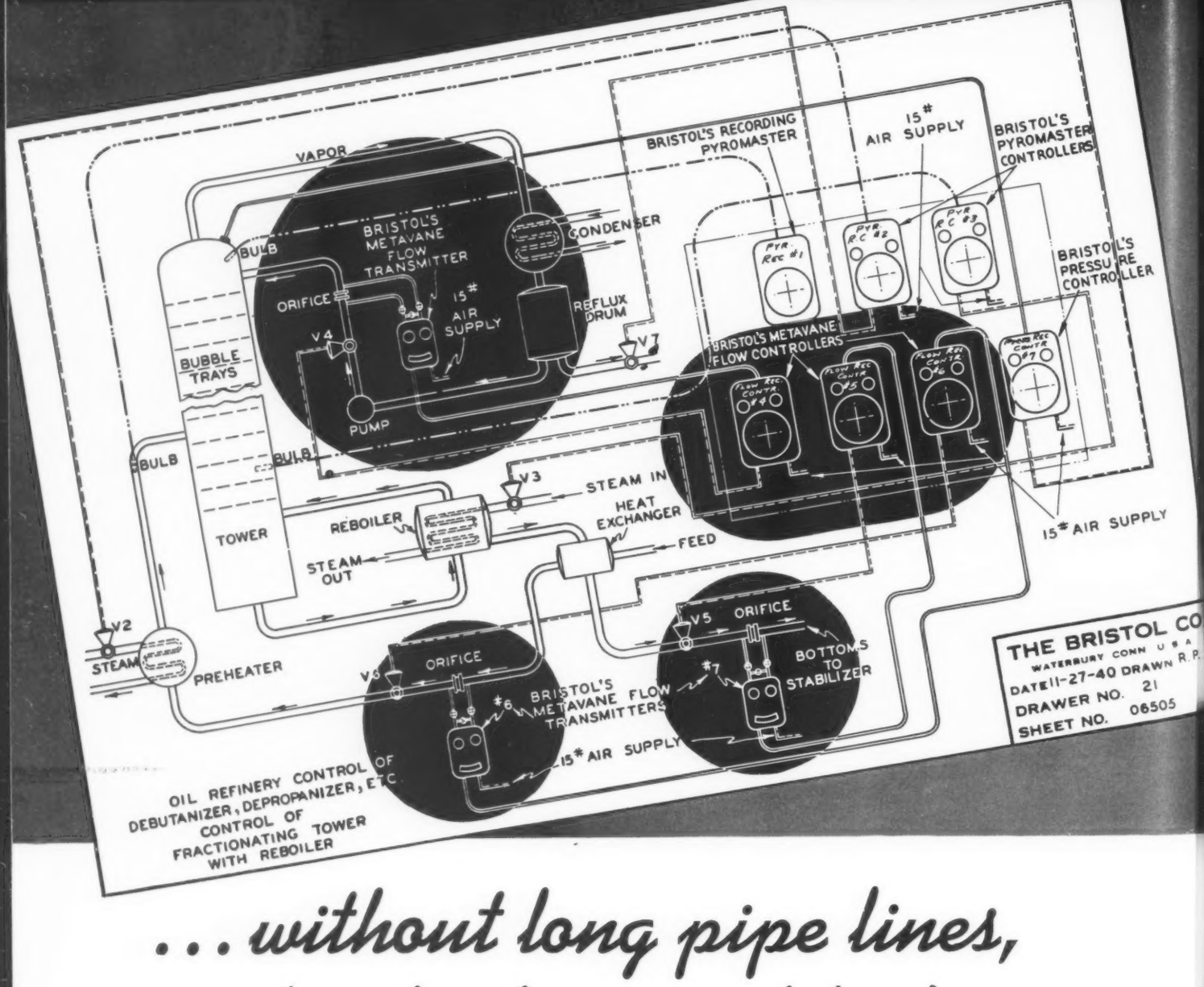
ELECTRIC RESISTANCE WELDED STAINLESS STEEL TUBING

Also Boiler Tubes • • • Condenser and Heat Exchanger Tubes • • • Mechanical Tubing

HOW THE CONTROL ROOM CAN SEE INSTANTL'H



. . . without long pipe lines, heads, danger of leaks

As shown in the flow sheet of debutanizer control, instrument men and engineers in the control room can constantly see what is happening in the pipe lines — yet with no long, costly and possibly leaky lines to the meter-body.

This striking example of Bristol's Metavane and its value, shows how it gives instantaneous record and control over flow. This pneumatically operated instrument eliminates all danger of explosion and can, therefore, be used with the greatest safety in the hazardous atmospheres encountered in refineries.

Bristol's Extra Refinements

SALES ENGINEERS IN HOUSTON, TULSA, LOS ANGELES, NEW YORK, CHICAGO, AND OTHER MAJOR REFINING CENTERS

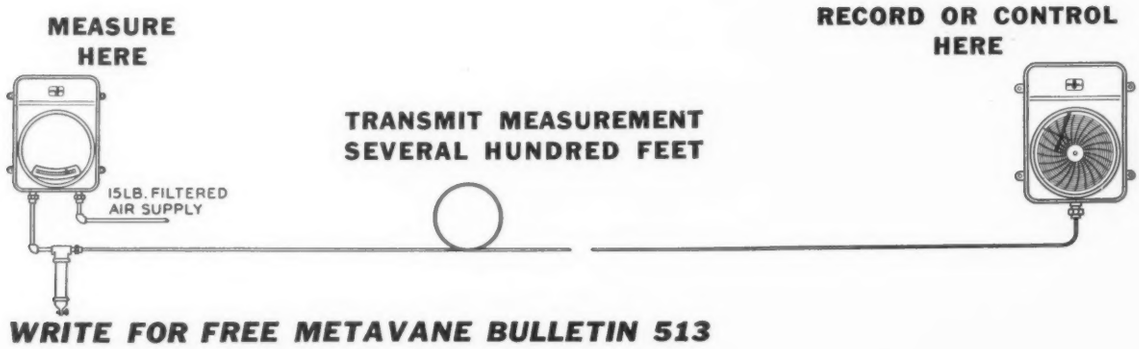
THE FLOW IN PIPES HUNDREDS OF FEET AWAY

WHAT IS BRISTOL'S METAVANE?

It is a simple system of telemetering facts from the point where measurements are pneumatically transmitted to a central spot. The Transmitter (which is essentially a Bristol's Free-Vane Pressure Controller) is connected to a Receiver, hundreds of feet away.

The Transmitter operates on Bristol's Free-Vane principle and controls the air pressure on the line to the Receiver in amounts proportional to the quantity under measurement.

The Receiver can be either a recorder or a recording controller. The measuring system of the recorder is extremely simple — it operates on the Bristol Recording Gauge Principle. Controllers are the Bristol's Recording Free-Vane type and are furnished in On or Off, Ampliset, Reset or Pre-Set types. Extreme accuracy and instant response of the controller are ensured by Bristol's unique Free-Vane mechanism. This mechanism eliminates all drag on the measuring element, hence *no distortion nor delay.*



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BRISTOL'S INSTRUMENT CO., LTD. LONDON, N.W.10, ENGLAND

Those tangents on WeldELLS are for you!

THE accurately formed straight segments on each end of every WeldELL are placed there for *your* benefit—to give *you* better engineered piping at lower cost.

They keep the weld away from the zone of highest stress, make lining up easier and facilitate the use of slip-on flanges with WeldELLS.

Tangents provide just one of *eight* good reasons for insisting on WeldELLS. Seven other extra value features are listed below.

► WeldELLS and other Taylor Forge Fittings for Pipe Welding and Forged Steel Flanges are stocked by authorized distributors in all principal cities. Ask your local distributor for a copy of Taylor Forge Catalog No. 401.

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WeldELLS have *everything* —

No other fittings for pipe welding combine these eight features. In addition to tangents these features are:

1. **Seamless**—Greater strength and uniformity.
2. **Precision quarter-marked ends**—simplify layout and help insure accuracy.
3. **Selective reinforcement**—provides uniform strength.
4. **Permanent and complete identification marking**—saves time and eliminates errors in shop and field.
5. **Wall thickness never less than specification minimum**—assures full strength and long life.
6. **Machine tool beveled ends**—provide best welding surface and accurate bevel and land.
7. **The most complete line of Welding Fittings and Forged Steel Flanges in the World**—insures complete service and undivided responsibility.

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In Any Service.....
THE DISC IS LIFTED DIRECTLY AWAY FROM ITS SEAT BEFORE IT STARTS TO MOVE TO THE OPEN POSITION. ASSURING EASY OPERATION.

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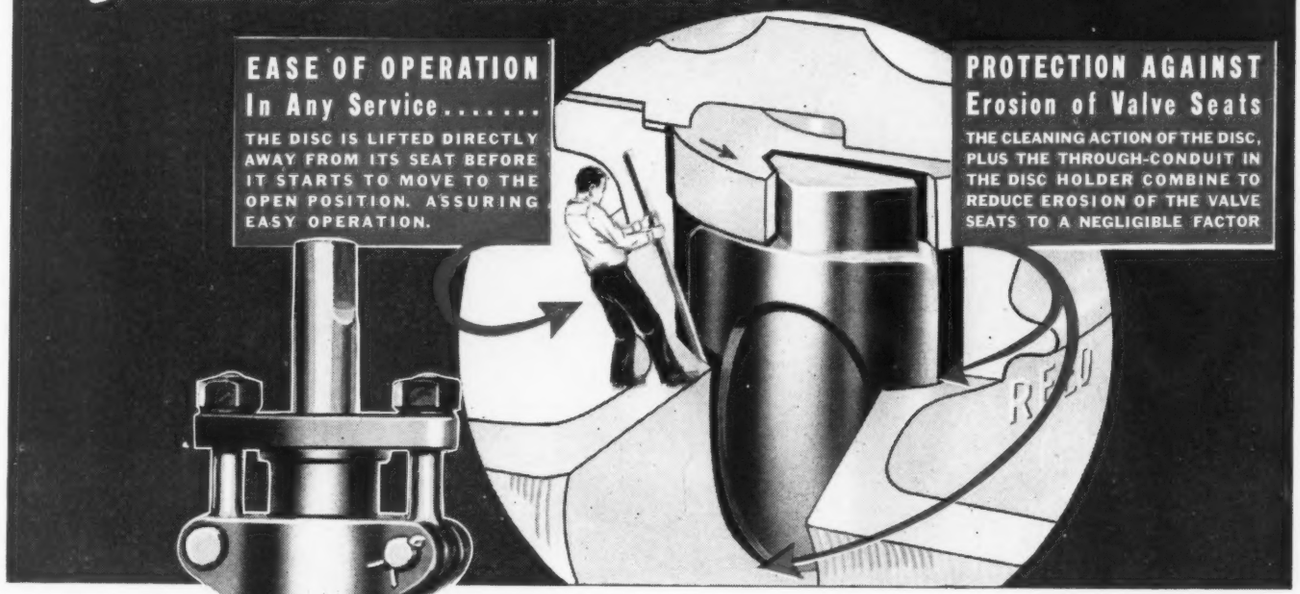
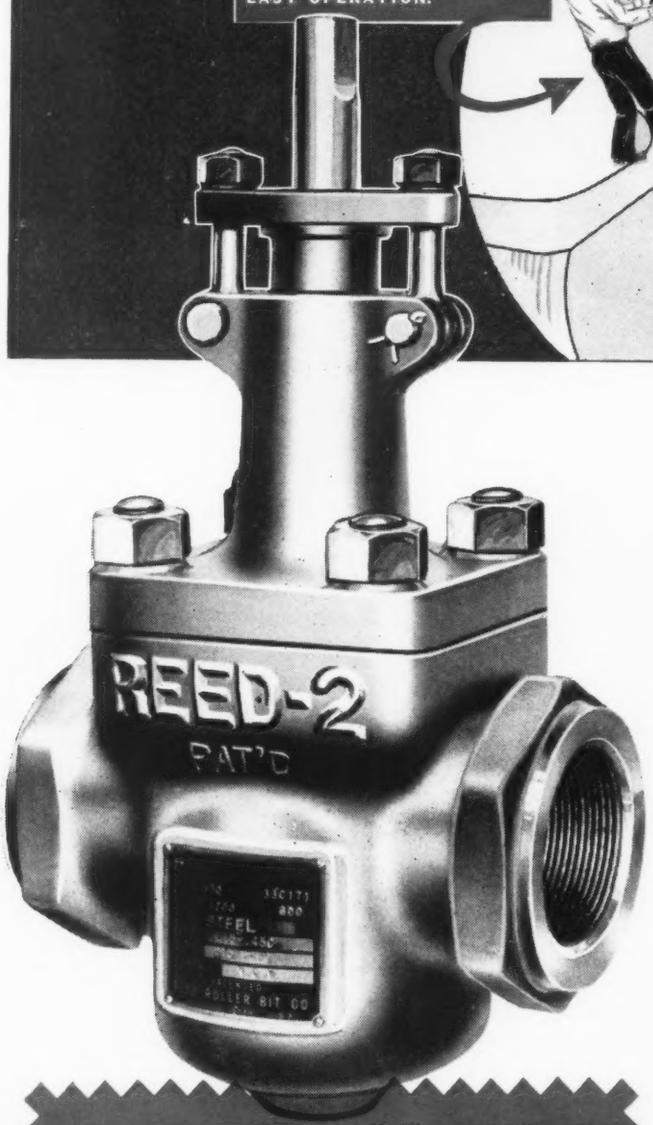
THE CLEANING ACTION OF THE DISC, PLUS THE THROUGH-CONDUIT IN THE DISC HOLDER COMBINE TO REDUCE EROSION OF THE VALVE SEATS TO A NEGLIGIBLE FACTOR





EASE OF OPERATION

PROTECTION AGAINST VALVE SEAT EROSION

—two important points to consider on your next valve problem.

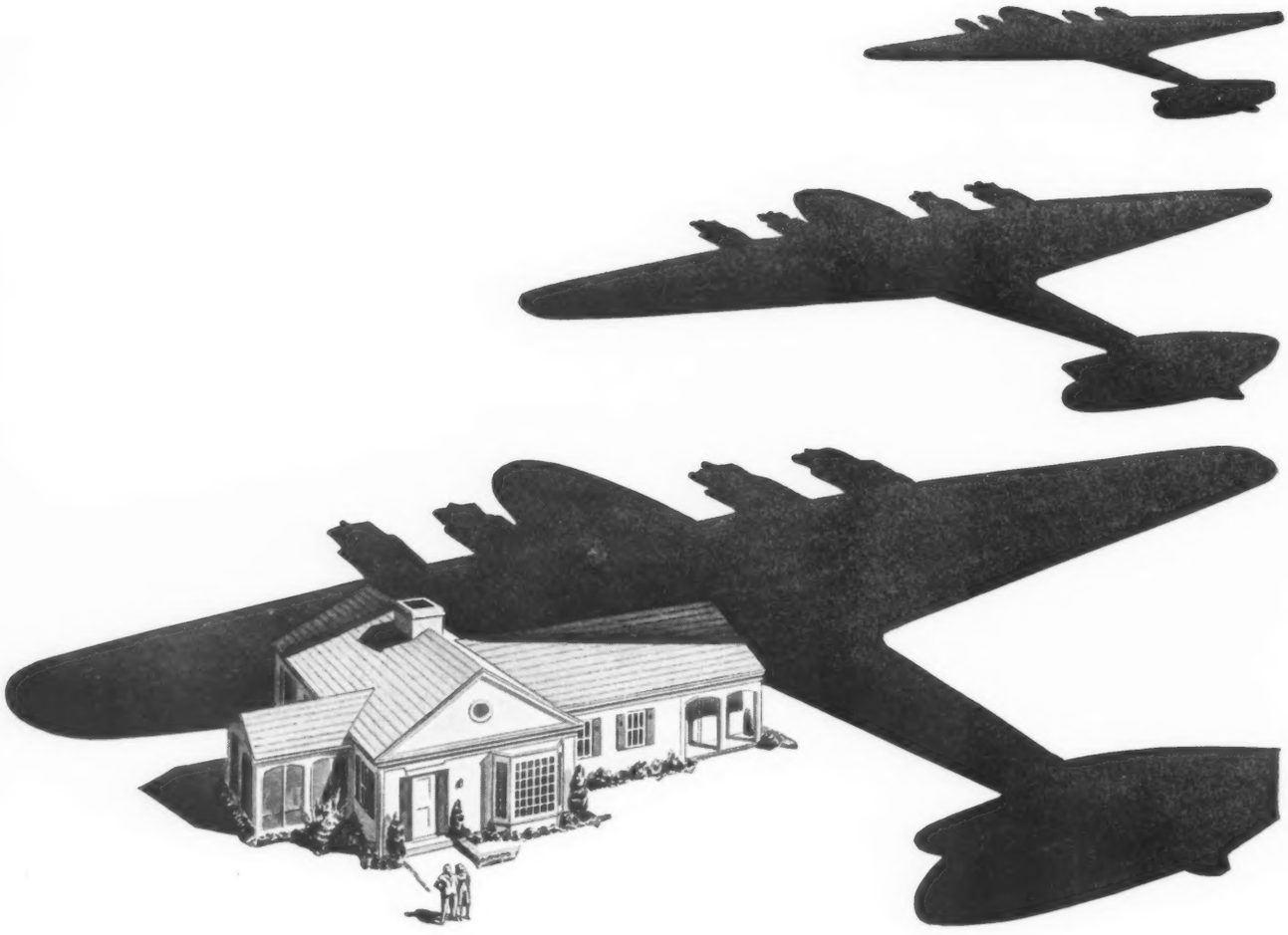
Reed Valves, through the lifting action of the disc, assure ease of operation in any service, and the cleaning action of the disc, plus the through-conduit in the disc holder, reduces erosion of the valve seats to a minimum and assures tight seating at all times.

Send for the Reed Valve Catalog 41 NOW. Reed Valves will help you reduce <u>your</u> valve maintenance costs.

REED VALVE DIVISION
of the REED ROLLER BIT COMPANY
P. O. BOX 2119 HOUSTON, TEXAS

Gentlemen:
Please send me your 1941 Catalog.
Name_____
Title_____
Company_____
Address_____

REED VALVE DIVISION
REED ROLLER BIT CO.
HOUSTON, TEXAS U. S. A.



WHEN THE SHADOWS ARE GONE . . .

As spring follows winter, so peace will return, allowing the world to resume its progress to better ways of doing things. Far-sighted men are thinking of the future, keeping tomorrow in mind while doing today's urgent task.

Today we of Keasbey & Mattison willingly give precedence to orders from defense industries, as you would have us do. Our plants are running day and night, we are enlarging our working force and adding to our machine capacity. Even so we are finding it difficult at the present time to deliver some products to many of our customers.

But, like you, we are keeping one eye on the future. When normal times return . . . when we are able to ship you everything you want, when you want it . . . we expect to have found ways of doing things better, offering you asbestos products that will last longer, prove more economical and serve your purposes better.

To that end, we need your help now. Can you, who use asbestos materials, give us some ideas for tomorrow? Have you encountered some specific problem that could be overcome by a new application of asbestos? We will give thorough consideration to any suggestion, in the hope that it will prove to be practical from a manufacturing standpoint. We'd greatly appreciate a letter from you.

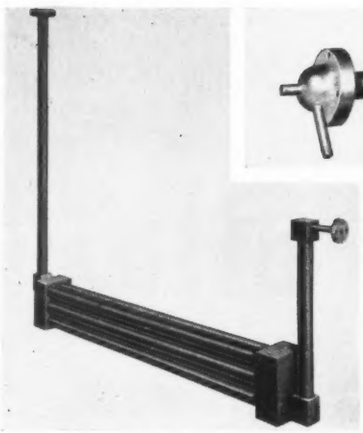
* * *

Nature made asbestos;
Keasbey & Mattison has made it serve mankind . . . since 1873.

K&M best in asbestos

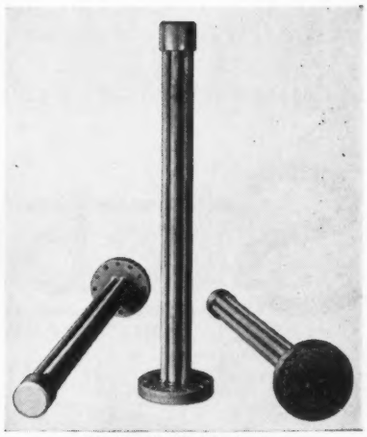
KEASBEY & MATTISON
COMPANY, AMBLER, PENNSYLVANIA

Bayonet Type Heat Exchanger



Immersion Type Heat Exchanger

Rapid Transfer of Heat



Tube Bundle Heat Exchanger

AND FREEDOM FROM CORROSION ARE OBTAINED BY USING

Karbate* NO. 2

TRADE-MARK

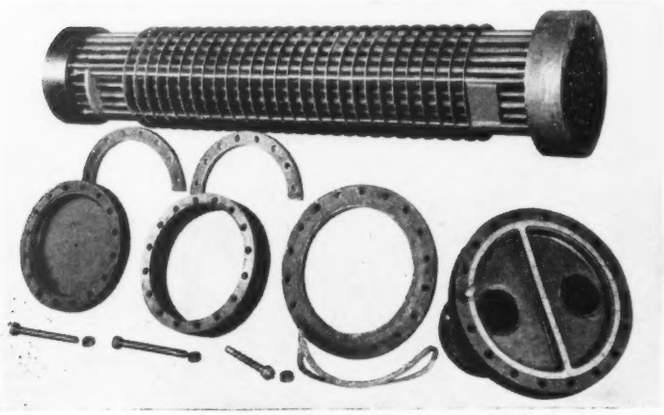
PIPE AND FITTINGS

FOR THE CONSTRUCTION OF HEATING OR COOLING COILS, EVAPORATORS AND OTHER HEAT EXCHANGE EQUIPMENT USED IN CONTACT WITH CORROSIVE MATERIALS

* "Karbate" is the trade-mark for a carbon or graphite base material impervious to seepage of fluids under pressure.

● "Karbate" No. 2 pipe has heat transfer properties equal to steel pipe of corresponding diameter. It is unaffected by salt water as well as most acids, alkalies and other corrosive materials.

Hundreds of heat exchangers of "Karbate" construction are in successful use. These represent many varied types, a few of which are illustrated on this page.



Elements for Shell and Tube Type Heat Exchanger

Return Bend Cooling Coil

National Carbon Co., Inc.
Cleveland, Ohio.

Gentlemen: Please send me information on the use of "Karbate," Carbon or Graphite materials for the application named.

APPLICATION CONSIDERED _____

NAME _____

FIRM _____

CITY _____ STATE _____

R

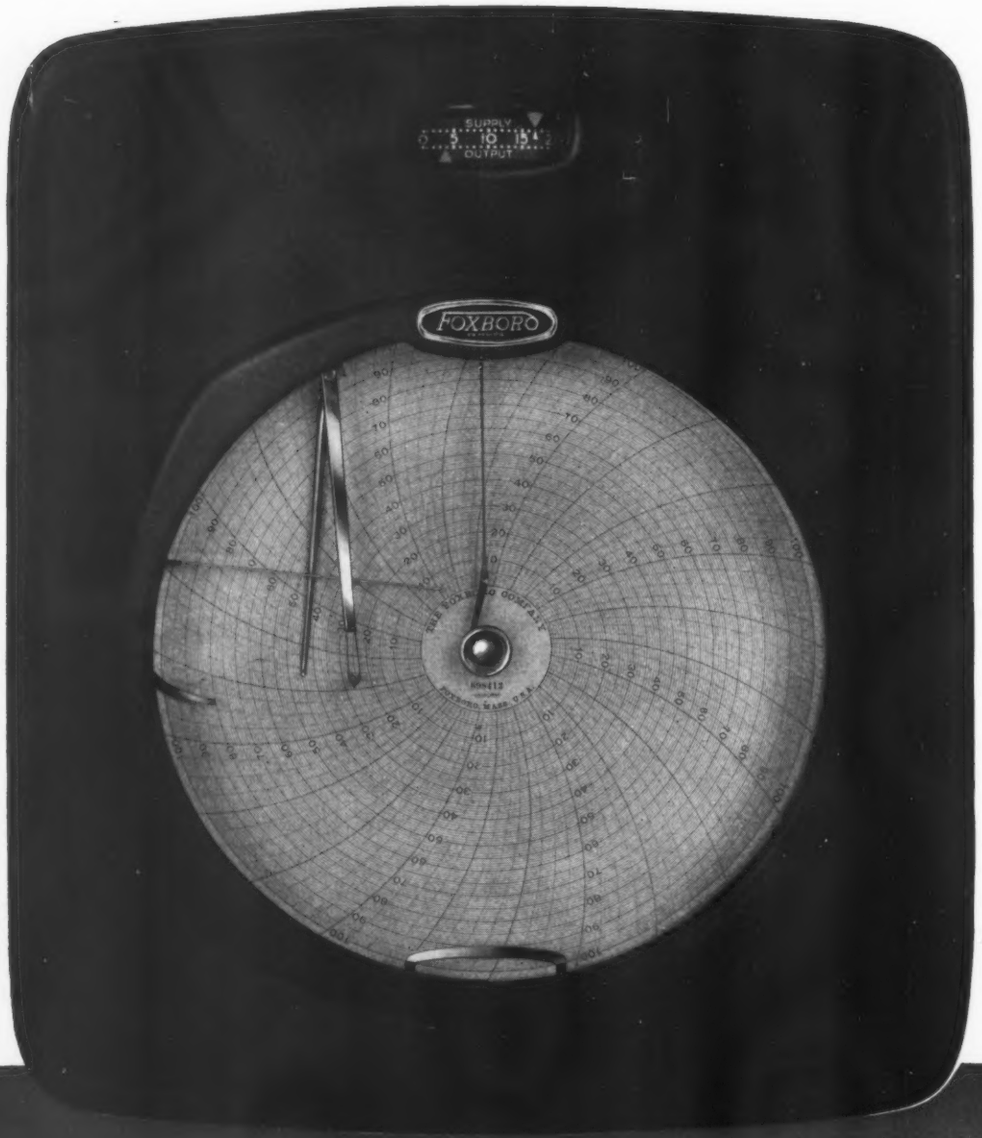
NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC

Carbon Sales Division, Cleveland, Ohio
GENERAL OFFICES
30 East 42nd Street, New York, N. Y.
BRANCH SALES OFFICES
New York, Pittsburgh, Chicago, St. Louis, San Francisco

MODEL 30

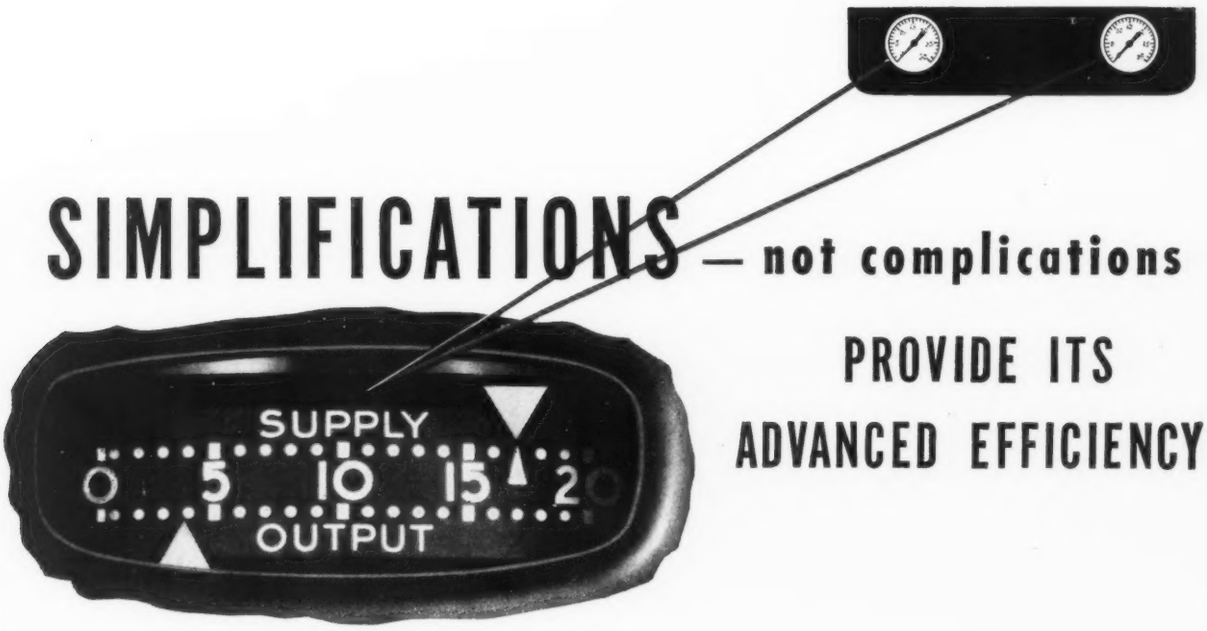
Stabilog Controller

REG. U.S. PAT. OFF.



Advances in Model 30 Stabilog Controller include this distinctive new case. It sets a new high standard of functional beauty in flush-mounted rectangular case design.

For Temperature, Pressure, Flow or Liquid Level



SIMPLIFICATIONS — not complications

PROVIDE ITS ADVANCED EFFICIENCY!

Typical of many Foxboro refinements is the single, quick-reading dual-indicator to replace two separate pressure gauges.

• • •

It's not a matter of added gadgets, but carefully-engineered simplifications, that makes the Model 30 Stabilog Controller a revolutionary advance in stabilizing control. This new instrument incorporates mechanical refinements never before employed to eliminate friction, lost motion and possibilities of human errors in controller operation.

Surer, Easier Manipulation

Even secondary elements such as air-pressure gauges have gained added utility through simplified design. In the Model 30, an exclusive new dual pressure indicator replaces the two separate gauges usually employed in air-operated instruments. At a glance, both supply and output pressures are instantly read on the compact edgewise scale.

Throttling range and reset adjustments, too, are simplified to permit speedy, accurate setting. They're readily accessible to authorized instrument men, but safely locked against tampering.

Vital Interior Refinements

Eleven years' experience with over 10,000 installations have revealed no need for fundamental changes in the original Stabilog Control principle. Yet, many additional refinements throughout the mechanism of the new Model 30 Stabilog Controller reduce friction and lost motion even further . . . increase sensitivity and response to a degree that enables use of smallest, most efficient proportioning band values.

Get Full Details

These are only a few "high lights" of the new Model 30 Stabilog Controller. For detailed description and discussion, write for Bulletin A252. It explains why Model 30 is attracting widespread attention in process industries by its smoother, closer control. **The Foxboro Company, 74 Neponset Avenue, Foxboro, Mass., U. S. A.**

Creative Instrumentation

by FOXBORO

REG. U. S. PAT. OFF.

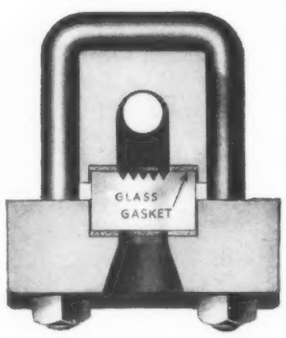
JERGUSON

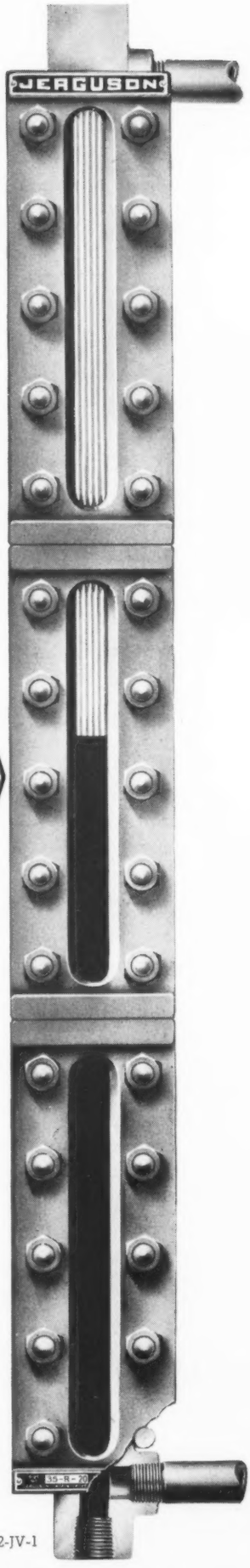
Reflex Gages

U-Bolt Assembly Gives Added Safety

PARTS of forged steel and alloy steel, no matter how strong in themselves, are no stronger than the assembly. In Jerguson Reflex Gages, the assembly is held together by bar steel U-bolts which add materially to the strength of the gage.

These Reflex Gages are designed for pressures up to 1200 pounds at 1000° F. and up to 3200 pounds at 100° F. When asking for information, give details of service required.





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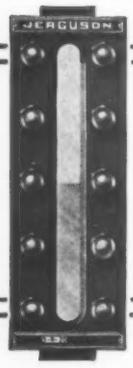


JERGUSON

Transparent Gages

Designed for use when color and density of liquid as well as level must be noted. Recommended for pressures up to 600 pounds at 1000°F. and up to 2000 pounds at 100°F.

JERGUSON GAGE & VALVE CO.

87 FELLSWAY SOMERVILLE, MASS.

Desco Corporation
2nd & Welsh Sts.,
Chester, Pa.

Bushnell Controls & Equipment Co.
(All of California)
117 West Ninth St.,
Los Angeles, Calif.

W. D. Emery Co.
1015 McBirney Bldg.,
Tulsa, Okla.

O'Brien Equipment Co.
2726 Locust Boulevard,
St. Louis, Mo.

J. Arthur Moore
342 Madison Ave., N. Y. C.

Associated Valve & Engineering Co.
510 North Dearborn St.,
Chicago, Ill.

H. R. Bowers
1758 Wright Ave.,
Cleveland, Ohio
Rocky River Branch

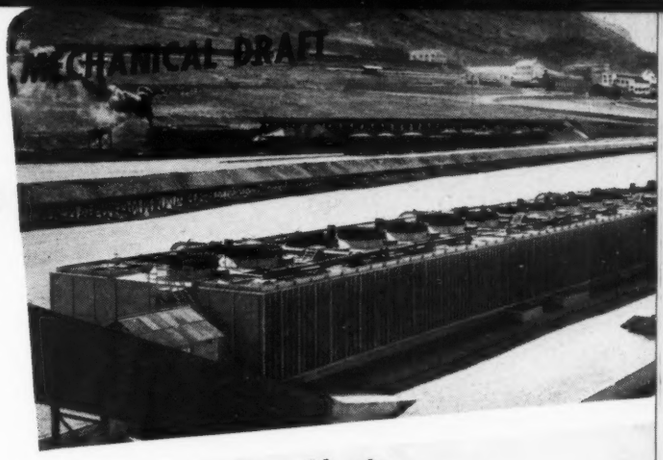
The J. A. Rossiter Co.
Houston, Texas

Murray-Baker-Frederic, Inc.
620-630 S. Peters St.,
New Orleans, La.

Paul B. Huyette Co., Inc.
401 North Broad St.,
Philadelphia, Pa.

PERFORMANCE *is the Final Test of Value*

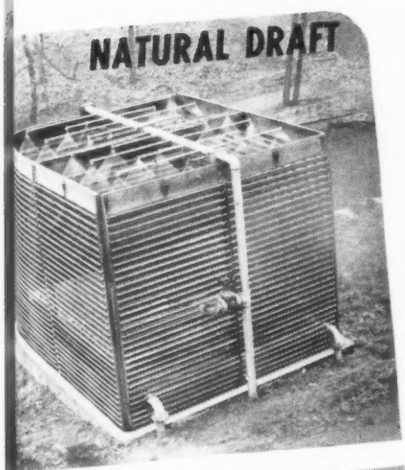
So Look at the PERFORMANCE RECORDS

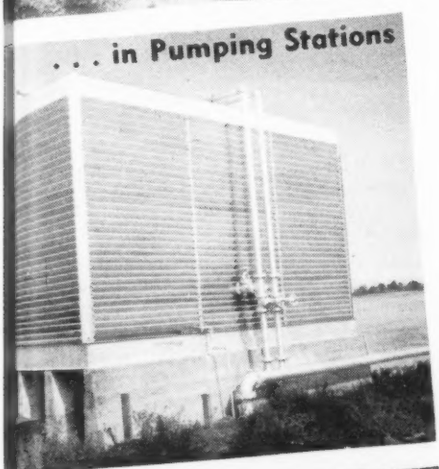


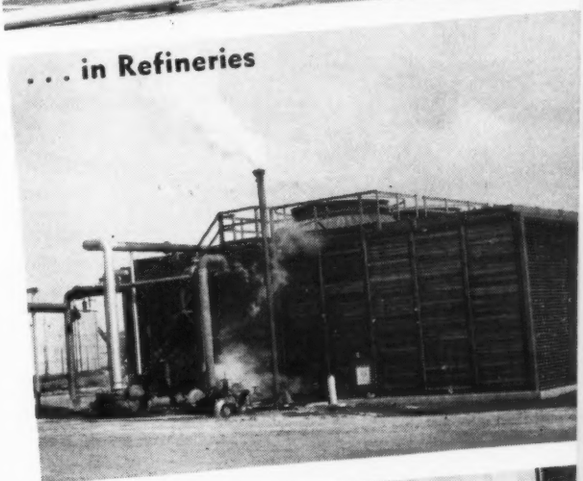
1. Solid facts and figures, the results of numerous tests conducted at random among the hundreds of Marley cooling towers operating in every kind of oil and gas industry service, prove the reliability of Marley's definite performance guarantees.

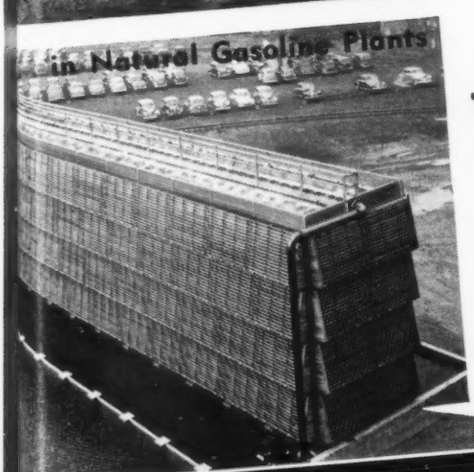
2. Also compare the other indicators of satisfactory performance: the manufacturer's percentage of repeat orders, the number and calibre of oil and gas companies that are regular purchasers, the volume done by the manufacturer as a percentage of the total cooling tower volume for all manufacturers, the facilities and reputation which are the only factors giving value to any manufacturer's performance guarantees.

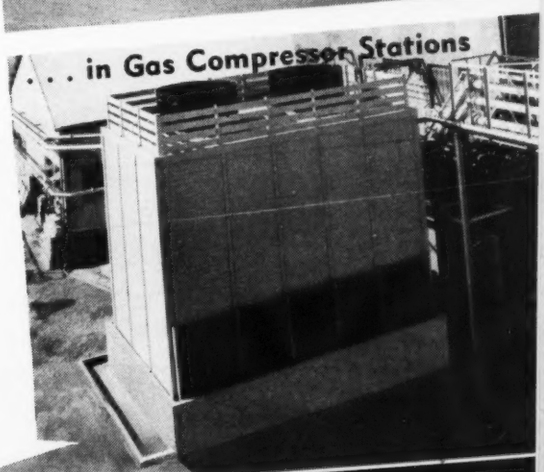
Look at the *whole* record and buy on the basis of proved performance! Without obligation, receive Marley's recommendations on any question involving water cooling equipment. In 36 major cities or write —









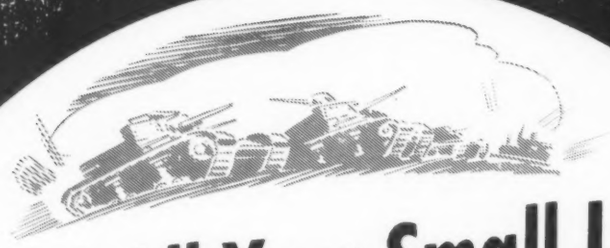


The MARLEY Company
Fairfax and Marley Roads
Kansas City, Kansas

ALL TYPES, ALL SIZES
and all variety of specialized adaptations to fit individual needs precisely.

MARLEY COOLING TOWERS

are saving money and promoting efficiency in plants, smallest to largest, in all phases of the oil industry

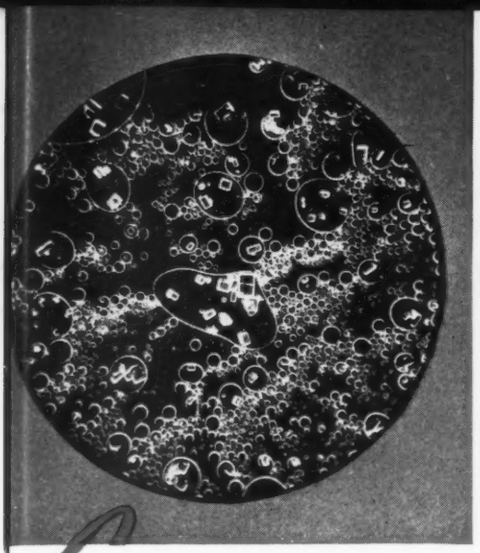


Guard All Your Small Lines with a Full "Armored Force" of CHAPMAN 960 Gate Valves

This tough, veteran valve turns back the attacks of wear with a special armor of super-hardened stainless steel on the interchangeable rising stem, seat rings and wedge. This means longer life than you can get from any similar type of small valve for general oil industry service.

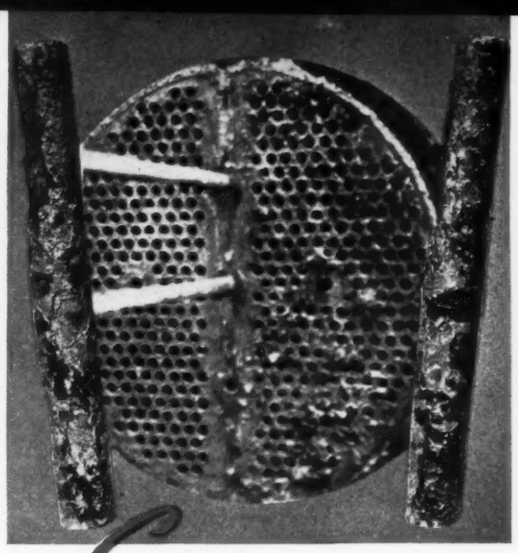
So for "total defense" from the usual small-valve troubles on all field and refinery lines up to 2" . . . put Chapman's List 960 in command of the situation. You can get it in sizes from ¼" to 2" . . . for pressures up to 800 lb. at 750° F. . . . and for cold working pressures up to 1500 lb. You can get it, too, in either inside or outside screw models, each with quick-acting, non-sticking threads. Get in touch now with the Chapman plant, or the nearest Chapman office.

THE CHAPMAN VALVE
MANUFACTURING COMPANY
INDIAN ORCHARD, MASS.



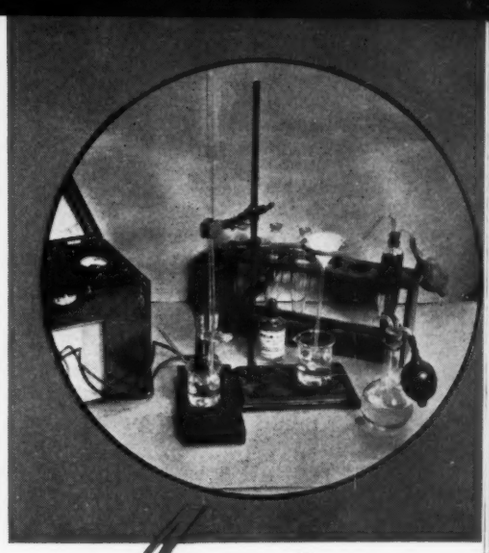
Cause

Unusual photomicrograph showing presence of salt crystals in crude oil and brine emulsion.



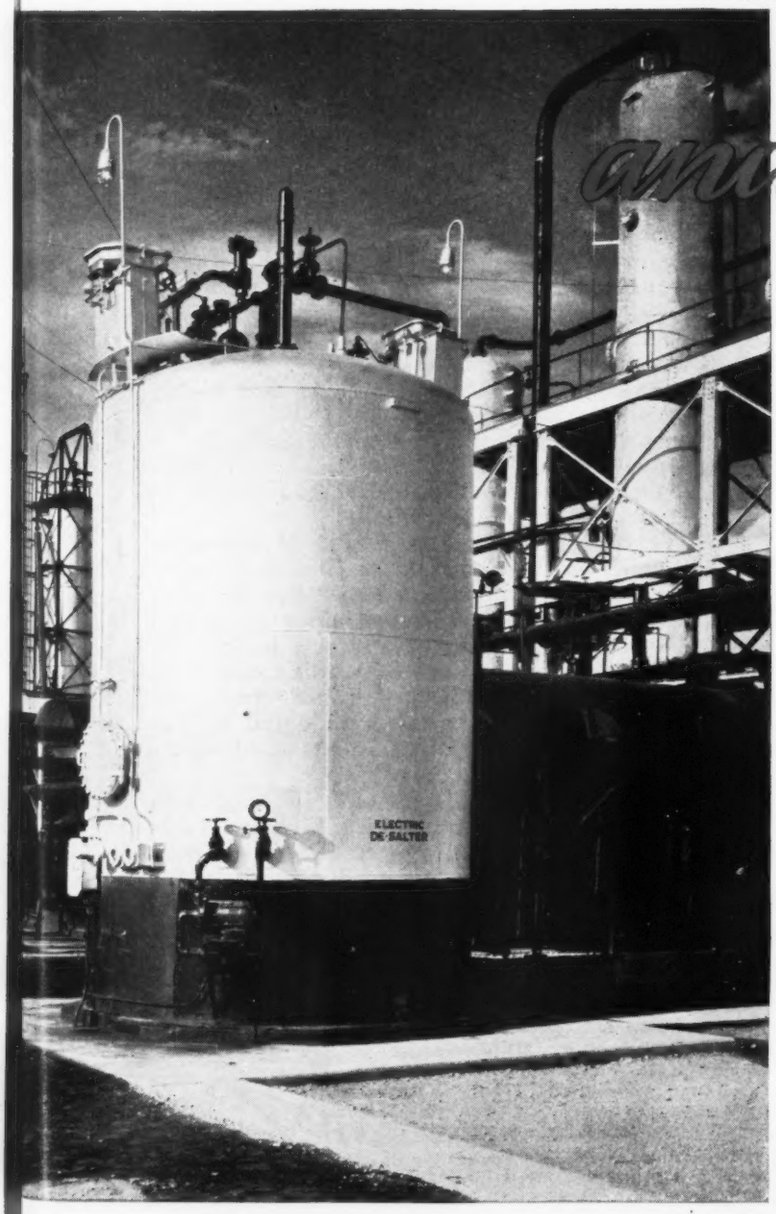
Effect

Lost "on stream time". Plugged, corroded and scaled refinery units. Raised maintenance costs. Frequent shutdowns.



Analysis

For an accurate analysis of your salt problem get in touch with Petreco. An expert survey of your problem involves no obligation.



and THE ANSWER

to corrosion, scaling, plugging and attendant salt troubles which cause frequent shutdowns is Petreco Electromatic Desalting. The completeness of this answer is graphically witnessed by the many Petreco installations in daily operation. Investigate the economies offered by Petreco today.

PETROLEUM RECTIFYING COMPANY OF CALIFORNIA
General Offices: **Los Angeles, California**

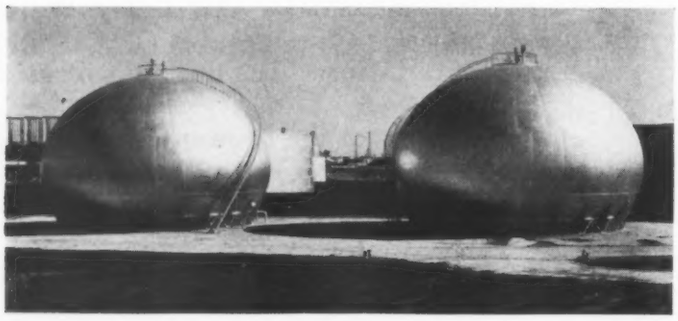
Gulf Coast Division: **Houston, Texas**
Eastern Division: **Toledo, Ohio**
Representatives In Principal Oil-Fields and Refining Centers

PETRECO

DESALTING **DEHYDRATING**

Protect the Quality of AVIATION GASOLINE by Storing it in HORTONSPHEROIDS

ABOVE: 25,000-bbl. Hortonspheroid installed at the Tide Water Associated Oil Co. refinery, Wilmington, Calif. BELOW: Two 30,000-bbl. spheroids installed at the Richfield Oil Corp. refinery, Wilmington, Calif.



TO operate at peak performance, the engines that power today's civil and military planes demand a higher quality fuel than ever before. For this reason, oil companies have steadily adopted more precise standards for aviation gasoline uniformity and quality. If gasoline were not volatile, this would not change storage requirements materially. As it is, however, the problems of maintaining high standards have multiplied.

Many present-day precision fuels are produced by blending. With modern highly volatile materials, mixing, either by mechanical means or by recirculation, in an ordinary tank accelerates evaporation. This means deterioration of product quality in addition to loss of volume.

It is for this reason that Hortonspheroids are widely used for blending operations. No evaporation loss takes place as long as the vapor pressure does not exceed the operating pressure for which the tank is designed. Instead of venting vapor to the atmosphere, the pressure above the liquid increases until it is equal to the vapor pressure of the contents and then no more liquid vaporizes.

Hortonspheroids are built in sizes up to 100,000 bbls. for handling high test fuels at pressures from 2½ to 20 lbs., and in capacities from 2,500 to 40,000 bbls. for pressures up to 30 lbs. per sq. in.

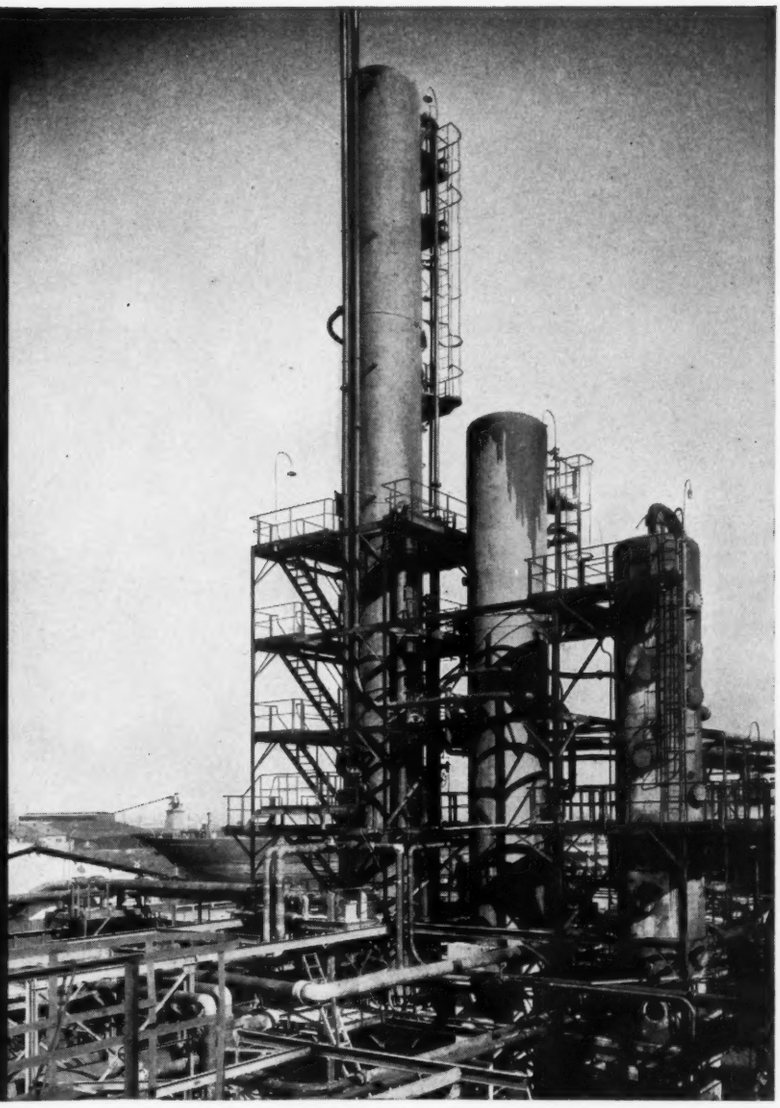
CHICAGO BRIDGE & IRON COMPANY

Houston.....5626 Clinton Drive	Chicago.....2463 McCormick Bldg.	New York...3302-165 Broadway Bldg.
Tulsa.....1626 Hunt Bldg.	Detroit.....1520 Lafayette Bldg.	Washington....811 Washington Bldg.
Birmingham.....1548 N. Fiftieth St.	Cleveland...2234 Builders Exchange	San Francisco.....1051 Rialto Bldg.
Havana.....402 Edificio Abreu	Philadelphia....1608-1700 Walnut St.	Los Angeles.....1434 Wm. Fox Bldg.

Fabricating Plants in BIRMINGHAM, CHICAGO, and GREENVILLE, PA.

LICENSEES: Horton Steel Works, Limited, Fort Erie, Ontario, Canada; The Motherwell Bridge & Engineering Co., Ltd., Motherwell, Scotland; The Whessoe Foundry & Engineering Co., Ltd., London, England; Worms & Cie., Paris, France; Compagnia Tecnica Industrie Petroli S.A.I., Rome, Italy.

High efficiency attained with Eagle Insulating Materials



...fabricated from chemically-and-physically stable mineral wool to meet a wide range of temperatures

NEVER before have refineries called for such high efficiency from insulating materials. Modern operating requirements have never been so exacting as they are today.

To meet these demands, Eagle-Picher makes available a line of insulations fabricated from a unique mineral wool —a mineral wool which is both chemically and physically stable.

Because it is honeycombed with millions of tiny dead air cells, Eagle Mineral Wool gives outstanding efficiency. And because it does not deteriorate under ordinary operating conditions, it retains full effectiveness over a long period.

Included in a long list of Eagle Insulating Materials for Oil Refineries are...

EAGLE SUPER "66"—a plastic product for temperatures as high as 1800° F. Extremely economical because of high coverage and minimum shrinkage. Great adhesiveness—easy to apply.

EAGLE BLANKET INSULATION—for temperatures to 1200° F. These blankets withstand expansion, contraction and other service conditions without deterioration.

EAGLE SUPERTEMP BLOCKS—all-purpose blocks effective for temperatures as high as 1700° F. Easily applied—lightweight. Resist steam and moisture.

★ ★ ★

EAGLE INSULSEAL—a durable, fire-resistant coating that protects all kinds of heat insulation against air infiltration, moisture, water, fumes.

EAGLE INSUL-STIC—a fibrous plastic material which binds blocks together until permanent support or final finish has been completed.

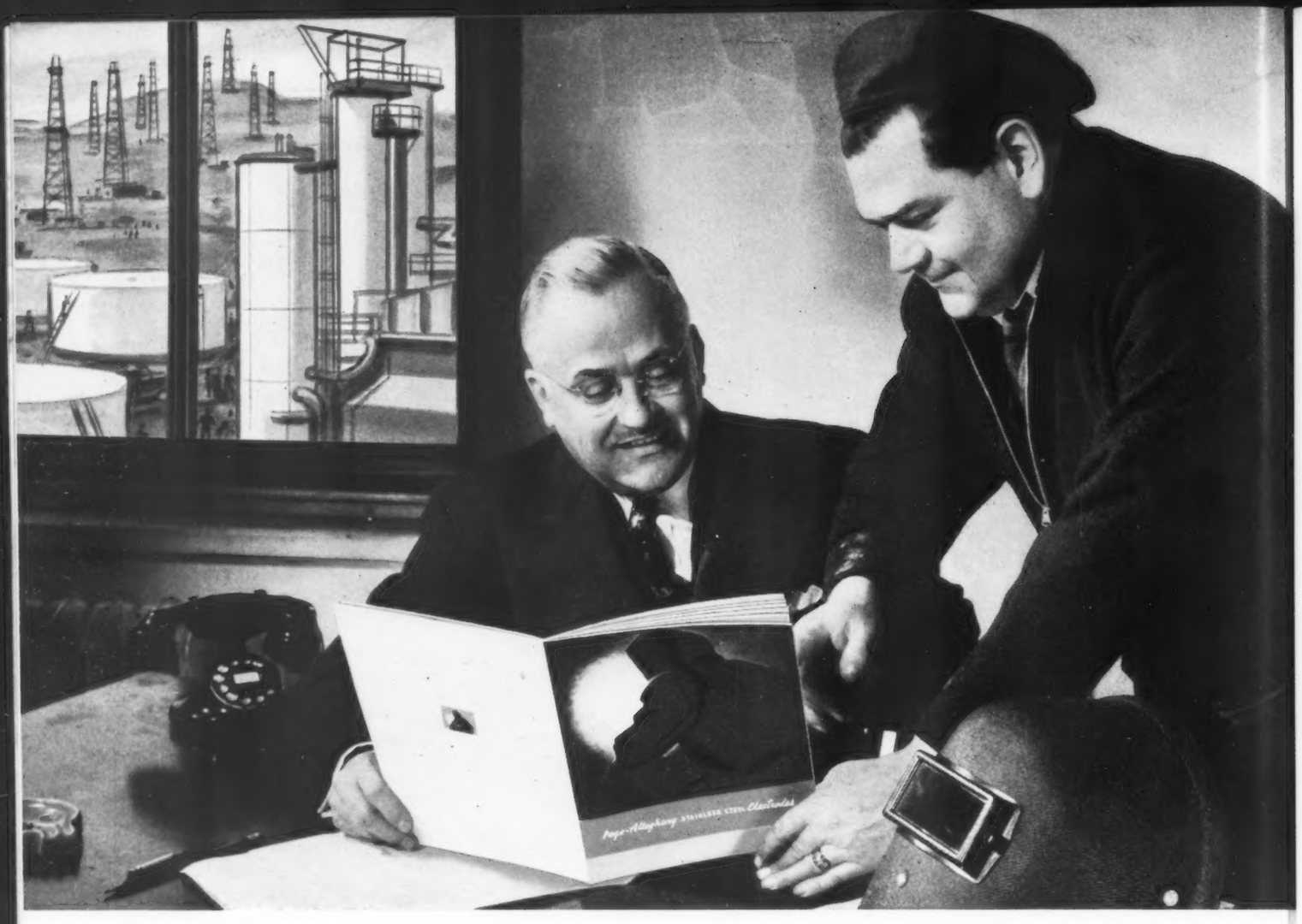
For complete specifications, see Sweet's Catalog.

Are YOU Using This Contracting Service?

Skilled, fully-qualified insulating engineers with the Eagle-Picher Contracting Division and Eagle Approved Contractors are available for collaboration with your engineers in specifying correct materials for jobs—and for supervising and handling complete application. Service widely used by many refineries.

Ask for details

EAGLE EP PICHER **THE EAGLE-PICHER LEAD COMPANY · CINCINNATI, OHIO**



"There's the Electrode we want for that Stainless Steel Welding"

YOUR local PAGE Distributor can give you a copy of a most interesting book on Stainless Steel welding and Stainless Steel Electrodes. . . . It simplifies the selection of your Stainless Steel Electrodes—makes it certain that the electrode your welders use gives you a deposit that equals the Stainless Steel they are welding . . . You can depend on PAGE-*Allegheny* STAINLESS STEEL ELECTRODES. Each of them has been produced in collaboration with the world's largest manufacturer of Stainless Steel. Sold by the PAGE Distributor in your locality.

PAGE

WELDING ELECTRODES

PAGE STEEL AND WIRE DIVISION • MONESSEN • PENNSYLVANIA

In Business for Your Safety

AMERICAN CHAIN & CABLE COMPANY Inc

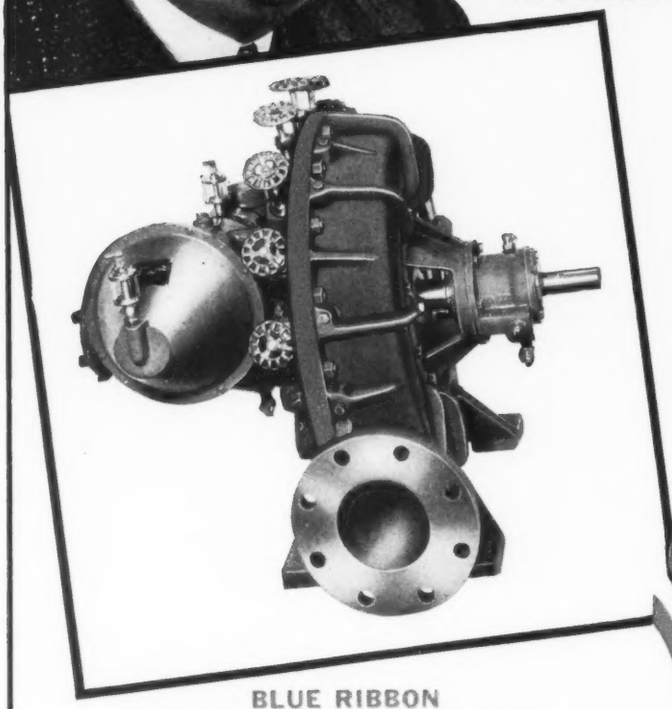
"I CAN'T TELL WHETHER IT'S RUNNING UNLESS I PLACE MY HAND ON THE SHAFT"

Says **PUBLIC UTILITY EXECUTIVE, OF COPPUS-TURBINE-EQUIPPED PUMP**

ANOTHER COPPUS BLUE RIBBON PRODUCT

A prominent pump manufacturer says that "numerous unsolicited testimonial letters, have come in from customers, praising the performance of this machine," a pump equipped with the Coppus Blue Ribbon Steam Turbine. One of the testimonials received by the pump manufacturer, is quoted in the caption above.

Such sweet-running, trouble-free performance is one of the main reasons why men like pumps to be equipped with Blue Ribbon Steam Turbines. The other reason is the economy of buying turbine equipment sized right for small jobs.



BLUE RIBBON INDICATES THESE ADVANTAGES

On all Coppus Products, the Blue Ribbon is a seal of precision and careful inspection. In the case of Steam Turbines, it means:

(1) Precision workmanship — controlled by Johansson size blocks
(2) Encased governor — slow speed, leverless
(3) Separate safety trip—pilot-operated, leverless
(4) Partial load economy — by individual nozzle control
(5) Dynamometer tested — before shipment

87% repeat orders, out of our 1940 Steam Turbine business. Operated by steam, gas, or air. Built-in speed reducers available. Vertical or horizontal types.

Write for full facts in free bulletin 135-9

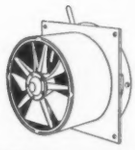
H. P. not E. P.* for Small H. P. jobs

*Elephant Power — a large-size turbine for a job a small-size Coppus could handle. Save investment cost with a Coppus Turbine sized close to your needs.

Coppus Engineering Corp., 459 Park Avenue, Worcester, Massachusetts. Sales offices in THOMAS' REGISTER. See REFINERY CATALOG for other "Blue Ribbon" products—air filters, gas burners, blowers, ventilators, fans.

COPPUS BLUE RIBBON PRODUCTS

Designed for your Industry
Engineered for You



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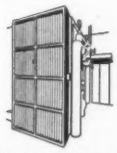

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COPPUS

INTO the flaming furnace of today's urgency are going many products admittedly new. From that furnace will evolve the better implements of tomorrow. Midvale is proud to share in today's urgent efforts, will be still prouder to share in tomorrow's progress.

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Vital for Defense

Efficient and economical plant operation is vital to attain the unprecedented production levels demanded by the National Defense program.

The dependability and long life built into every GARLOCK quality product today, as always, contributes to efficient plant operation by reducing production time losses due to shut-downs for frequent replacement of packings and gaskets.

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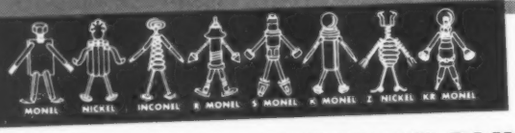
Garlock Packings

8 STRONG, RUSTLESS *Metals*



..each with a DIFFERENT PLUS!

Extra hardness, heat-resistance, non-magnetism, free-cutting and other qualities available in INCO Nickel Alloys

You doubtless know that Monel combines *strength* with excellent *resistance* to *corrosion*. But do you know that newer members of the INCO Nickel Alloy family combine varying degrees of strength with other useful properties? For example:

One of these metals is extra hard and non-galling; two are free-machining, two heat-treatable, one is non-magnetic, one especially adapted for high temperature service, while several make excellent spring materials for use under different conditions.

Knowing the *individual* characteristics of the INCO Nickel Alloys, will better enable you to meet the requirements of defense and other contracts. Write for the booklet, "*Individualized* INCO NICKEL ALLOYS." Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York, N. Y.**

	INDIVIDUALIZED CHARACTERISTICS	AVERAGE MECHANICAL PROPERTIES					
		Condition	Tensile Strength 1000 psi.	Yield Strength 1000 psi.	Elongation in 2 in. per cent	Hardness Brinell 3000 kg.	Impact Strength Izod
MONEL* 2/3 Nickel 1/3 Copper	GENERAL PURPOSE ALLOY Corrosion Resistance, Strength, Hardness, Toughness. Attractive Silvery White Color.	Annealed Hot-rolled Cold-drawn Cold-rolled, hard-temper	75 90 100 110	35 50 80 100	40 35 25 5	125 150 190 240	105 110 95
"R" MONEL* Contains the addition of .035% sulfur—	FREE CUTTING For High Speed Machining.	Hot-rolled Cold-drawn	85 90	45 75	35 25	145 180	96 99
"K" MONEL* Contains the addition of 2.75% Aluminum	EXTRA STRENGTH AND HARDNESS comparable to heat treated alloy steel. Heat Treatable. Non-magnetic.	Hot-rolled, As-rolled Hot-rolled, Heat-treated Cold-drawn, As-drawn Cold-drawn, Heat-treated	100 150 115 155	45 110 85 115	40 25 25 20	160 280 210 290	120+ 40 56 26
"KR" MONEL*	FREE CUTTING Extra Strength and Hardness. Heat Treatable. Non-magnetic.	Hot-rolled, As-rolled Hot-rolled, Heat-treated Cold-drawn, As-drawn Cold-drawn, Heat-treated	105 150 115 155	65 105 85 115	40 25 25 25	185 280 215 290	
"S" MONEL* Contains the addition of 4% silicon	EXTRA HARDNESS Non-galling.	Sand-cast, Annealed Sand-cast, As-cast Sand-cast, Heat-treated	90 130 130	70 100 100	3 2 2	275 320 350	
NICKEL 99.4% Nickel	CORROSION RESISTANCE Protection for Pure Products. Magnetic below 680° F. Good Electrical Conductivity.	Annealed Hot-rolled Cold-drawn Cold-rolled, hard-temper	70 75 95 105	20 25 70 95	40 40 25 5	100 110 170 210	120+ 120+ 120+
"Z" NICKEL* 98% Nickel	EXTRA STRENGTH AND HARDNESS Heat Treatable. Excellent Spring Properties. Good Electrical Conductivity. Magnetic.	Hot-rolled, As-rolled Hot-rolled, Heat-treated Cold-drawn, As-drawn Cold-drawn, Heat-treated	105 170 120 175	50 130 90 135	35 15 25 15	180 320 220 340	120+ 25 120+ 25
INCONEL* 80% Nickel 14% Chrome Balance—Iron	HEAT RESISTANCE Retains Strength. Resists Oxidation. High Corrosion Resistance.	Annealed Hot-rolled Cold-drawn Cold-rolled, hard-temper	85 100 115 135	35 60 90 110	45 35 20 5	150 180 200 260	120+ 110 85

*"MONEL" and other trade-marks which have an asterisk associated with them are trade-marks of The International Nickel Company, Inc.

INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • NICKEL • "Z" NICKEL

Sheet...Strip...Rod...Tubing...Wire...Castings

Oil Refining Processes

. . . for the production of aviation gasoline and aviation lubricants

Aviation gasoline

- **Alkylation**
- **Isomerization**
- **Selective polymerization**
- **Hydrogenation**
- **Hydrogen generation**
- **Stedman close fractionation**
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- **H_2S removal**
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Aviation lubricants

- **High vacuum distillation**
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Service

- **Laboratory analysis of available stocks, process design and engineering, fabrication, construction, and operation — all with undivided responsibility — are offered the industry to speed new construction and modification of existing plant facilities.**

FOSTER WHEELER CORPORATION **165 Broadway, New York, N. Y.**

FOSTER FW WHEELER

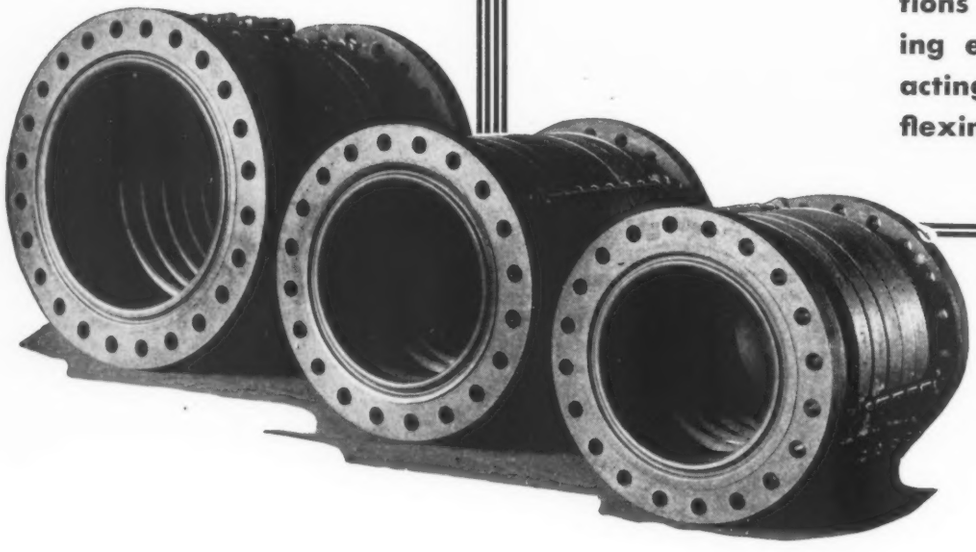
BADGER
Stainless Steel
EXPANSION JOINTS

SAVES . . . . space
insulation

ELIMINATES . packing
maintenance

DURABLE . . . under high
temperatures
under pressure
under corrosion

FUNCTIONS . . to the exclusive Directed Flexing design with all curve corrugations and corresponding equalizing rings acting to distribute flexing stresses



THE above just about covers everything that concerns the problem of the expansion in hot oil or gas lines and how to take care of this inevitable movement with a compact, long-lived, maintenance-free expansion joint.

E. B. BADGER & SONS CO.

75 PITTS ST., BOSTON, MASS.

AGENTS IN PRINCIPAL CITIES

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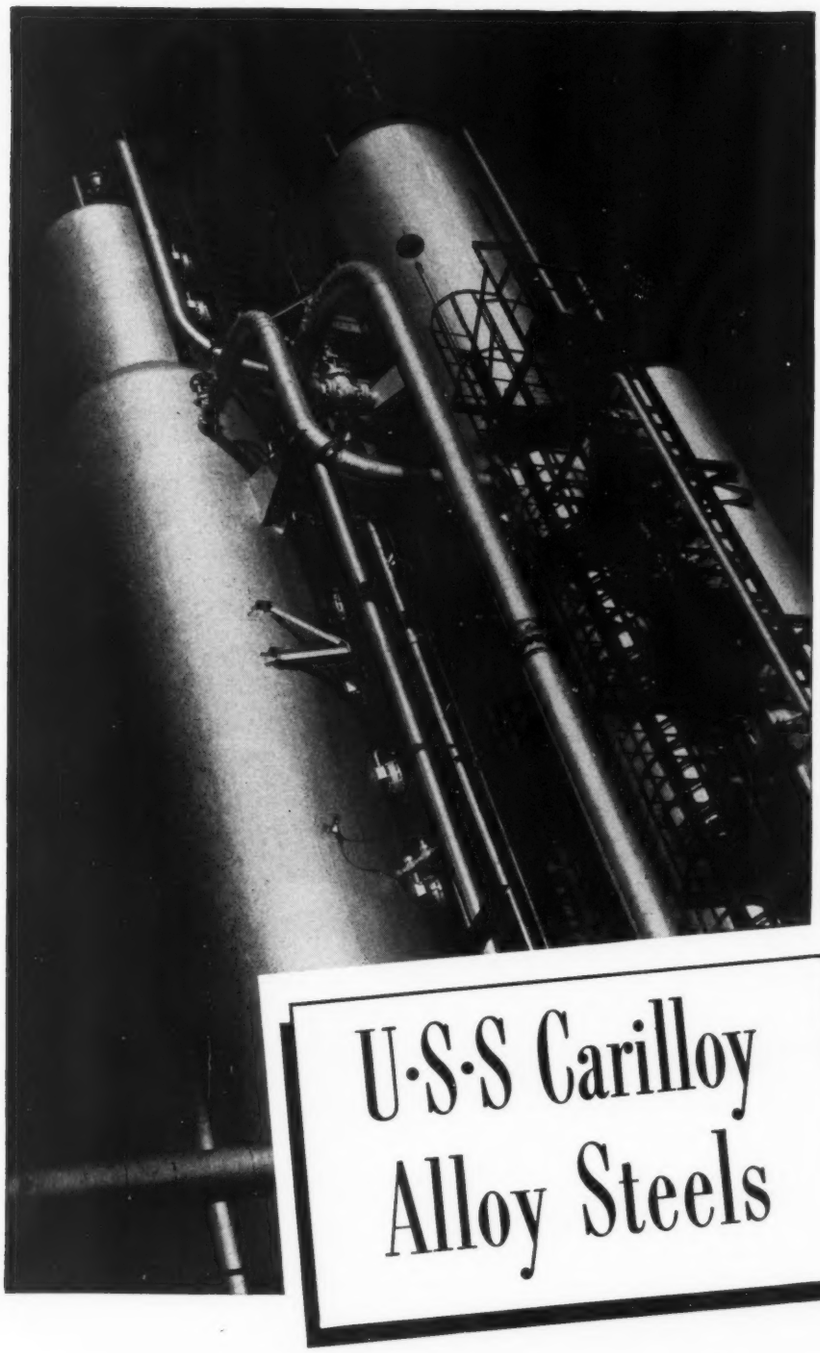
RIGHT NOW, THIS *"Specialized Knowledge"* OF STEEL CAN HELP YOU



U·S·S Carilloy Alloy Steels

TODAY, no user of oil field or refinery equipment, and especially no manufacturer of such products, can help but be aware that the steel picture is changing rapidly. Particularly is this true of alloy steels. Here a new resourcefulness is being required on the part of the steel maker to meet successfully a situation that bristles with difficulties.

Less familiar — but not unproved — alloying elements are being increasingly employed. Certain of these elements have been growing in use, steadily, during the past decade. They are now apparently destined to play an ever more dominant role.

Facts like these—and the urgent demands for production today—call for a re-examination and re-orientation of your alloy steel set-up. It may make imperative some revision of shop practices. It means that new methods of doing some jobs must be discovered.

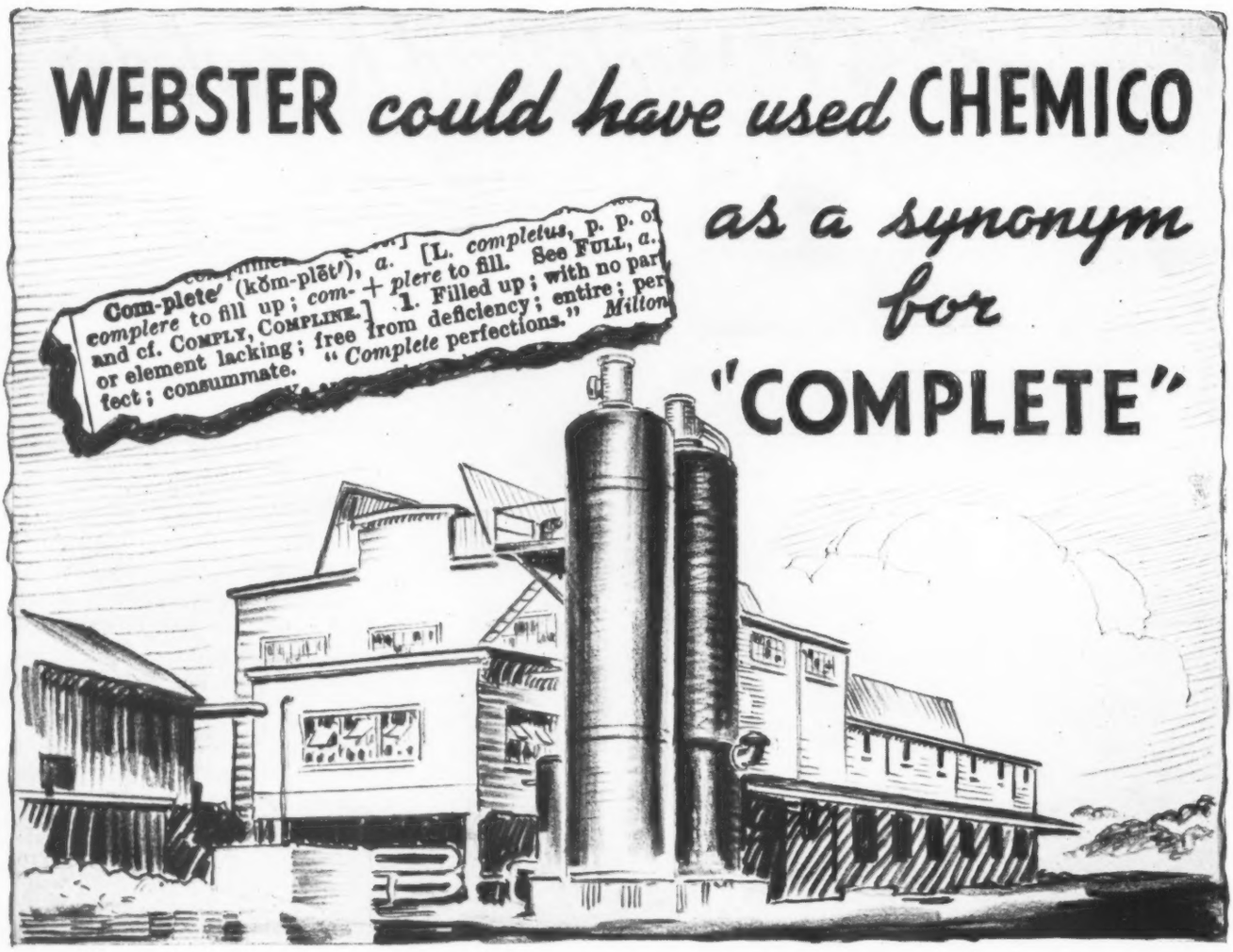
Here's where this specialized knowledge of our metallurgical contact staff can help you. They are working right on the firing line where the smoke of production is thickest. They are prepared to help you work with the materials available. And they can help you make the most efficient use of existing plant facilities. It's a tough job to work out alone—we'll be glad to cooperate on it.

CARNEGIE-ILLINOIS STEEL CORPORATION
Pittsburgh and Chicago
Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Export Company, New York

USS

UNITED STATES STEEL

WEBSTER *could have used* CHEMICO *as a synonym for* "COMPLETE"


Com-plete' (kŏm-plēt'), a. [L. completus, p. p. of complere to fill up; com- + plere to fill. See FULL, a., and cf. COMPLY, COMPLINE.] 1. Filled up; with no part or element lacking; free from deficiency; entire; perfect; consummate. "Complete perfections." Milton

CHEMICO Acid Plant Service thoroughly fulfills the definition of COMPLETE, for no part or element is lacking.

CHEMICO is prepared to study and analyze your acid requirements, adapt existing processes or develop new processes for your needs, design the entire plant, supply and erect all necessary equipment and structures and, finally, train the operating crew and test the operation of the entire plant to assure meeting all guarantees.

CHEMICO brings to these multiple tasks 27 years of experience in specializing on acid plant design and construction, together with unexcelled resources and the services of world-renowned acid technologists.

CHEMICO Completeness further extends to satisfactory service, as evidenced by the many concerns in the United States and abroad who have purchased additional CHEMICO plants because of the completely satisfactory results obtained from their first CHEMICO plant.

The advice and authoritative recommendations of the CHEMICO engineers are offered without obligation. Your inquiry is invited.

CHEMICO — CHEMICAL CONSTRUCTION CORP.

CHEMICAL CONSTRUCTION CORPORATION • **30 ROCKEFELLER PLAZA, NEW YORK, N. Y.**

Cables: Chemiconst, New York • **European Representatives: Cyanamid Products, Berkhamsted, Herts., England**

CHEMICO PLANTS are PROFITABLE INVESTMENTS

LET THIS *"EASIER-TO-GET"* ALLOY FILL YOUR TUBING NEEDS

Containing less chromium than many of the intermediate alloys, B&W CROLOY 2¼ has higher creep strength (at 1000 F. to 1200 F.).

It may pay you to sacrifice some corrosion and oxidation resistance in favor of the lower cost-per-pound of CROLOY 2¼, relying on its extremely high creep strength to give you an ample margin of safety. The B&W research staff will be glad to advise you in regard to this.

For polymerization, reforming, and high pressure cracking of mildly corrosive stocks, CROLOY 2¼ is the *ideal* tube alloy. Its high creep strength provides greater safety or, because thinner walls can be used, lighter weight, lower cost and greater through-put.

●

FULL TECHNICAL DATA WILL BE SENT ON REQUEST

CREEP STRESS IN POUNDS/SQ. INCH FOR 1% ELONGATION			
CREEP RATE	1000 F.	1100 F.	1200 F.
1%-10,000 hrs.	16,350	9,200	4,175
1%-100,000 hrs.	7,600	4,910	2,510

CROLOY 2¼

TA-11

BABCOCK & WILCOX TUBES

HOT FINISHED COLD DRAWN ALLOY STEELS CARBON STEELS

THE BABCOCK & WILCOX TUBE COMPANY, BEAVER FALLS, PA.

Kelly

THE "GASOLINE AGE" IS JUST BEGINNING

WE STAND on the threshold of the real age of gasoline power.

Despite the great progress which has been made thus far in the development of automotive fuels and engines, only a fraction of the energy in gasoline is being utilized. The greatest significance of the developments which have been made to date lies in their value as part of the foundation for the far greater progress of the future.

In the establishment of this foundation for future progress, not only the actual technical results but also the manner of their achievement are of great importance. Fuel problems and engine problems once were considered as things apart, and they were handled accordingly. Today, it is realized that the entire automotive unit with its fuel and lubricant must be considered together. The result is that research on the development of fuels, engines and lubricants is coordinated to be of maximum benefit to automotive transportation as a whole.

From the standpoint of the fuel refiner, this coordinated development involves evaluating experimental fuels in the light of such factors as supercharging, super-compression, preignition, inlet manifold design and the characteristics of transmission systems, as well as in terms of refinery equipment costs, processing costs, yields, lead response and the conventional inspection data.

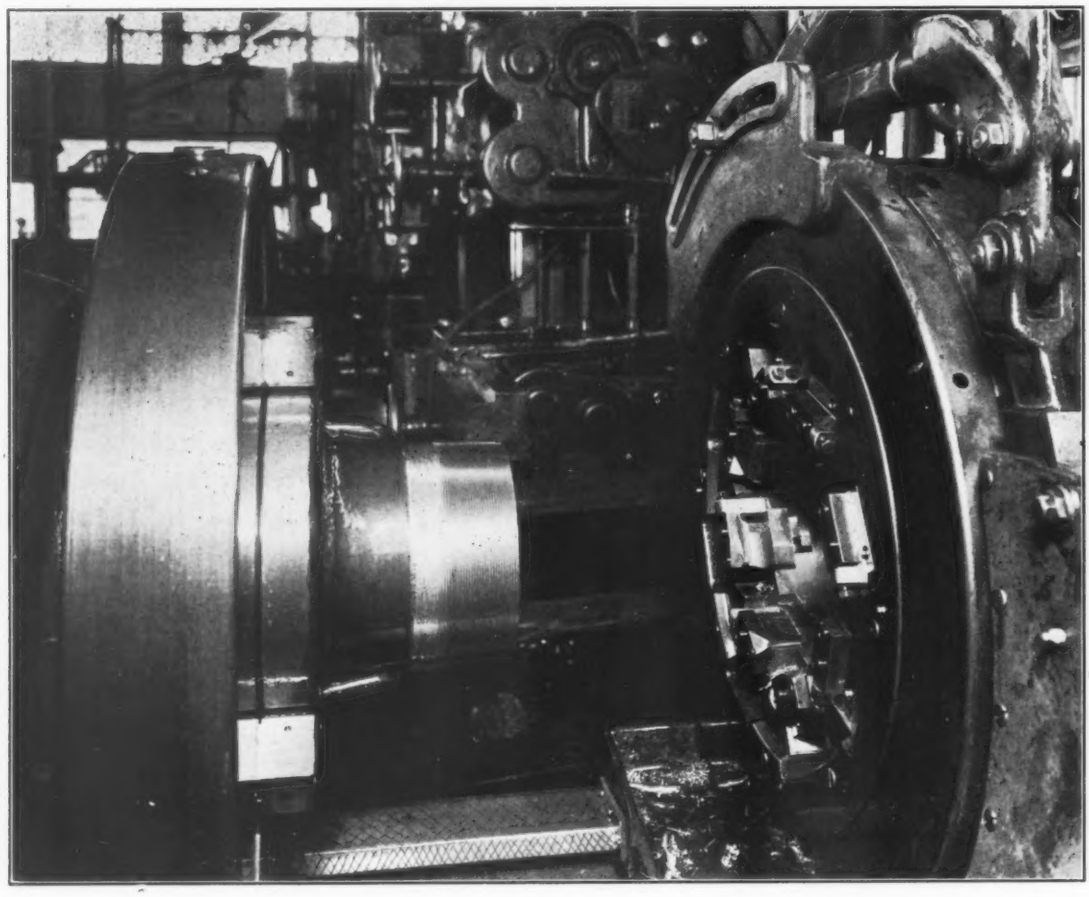
We of the Ethyl Gasoline Corporation have built up a wide experience in laboratory and field studies in which fuels and engines must be considered together, and our facilities are especially designed for such work. Our research and service workers welcome opportunities to cooperate in extending the usefulness of automotive transportation through the mutual development of fuels and engines, thus expanding the benefits of the "gasoline age."

ETHYL GASOLINE CORPORATION

Chrysler Building, New York, N. Y.

WITH ETHYL (TRADE MARK) REG. U.S. PATENT OFF. BRAND OF ANTI-KNOCK COMPOUND ETHYL GASOLINE CORPORATION REG. TRADE MARK

30 Minutes Saved Threading CASING HEADS with



LANDIS Pipe Threading Machines Equipped with Receding Chaser Die Heads

A southwestern company employs the LANDIS Receding Chaser Pipe Threading and Cutting Machine to thread Casing Heads.

The thread, 10¾" diameter, 8 pitch, 3⅝" long is produced at the rate of 3 per hour, to close A.P.I. tolerance specifications. By a previous method employed, 45 minutes were required to complete one Casing Head. Even though the material is tough steel forging which Brinells 220, the threads easily pass the most exacting inspection for Accuracy and Quality of Finish.

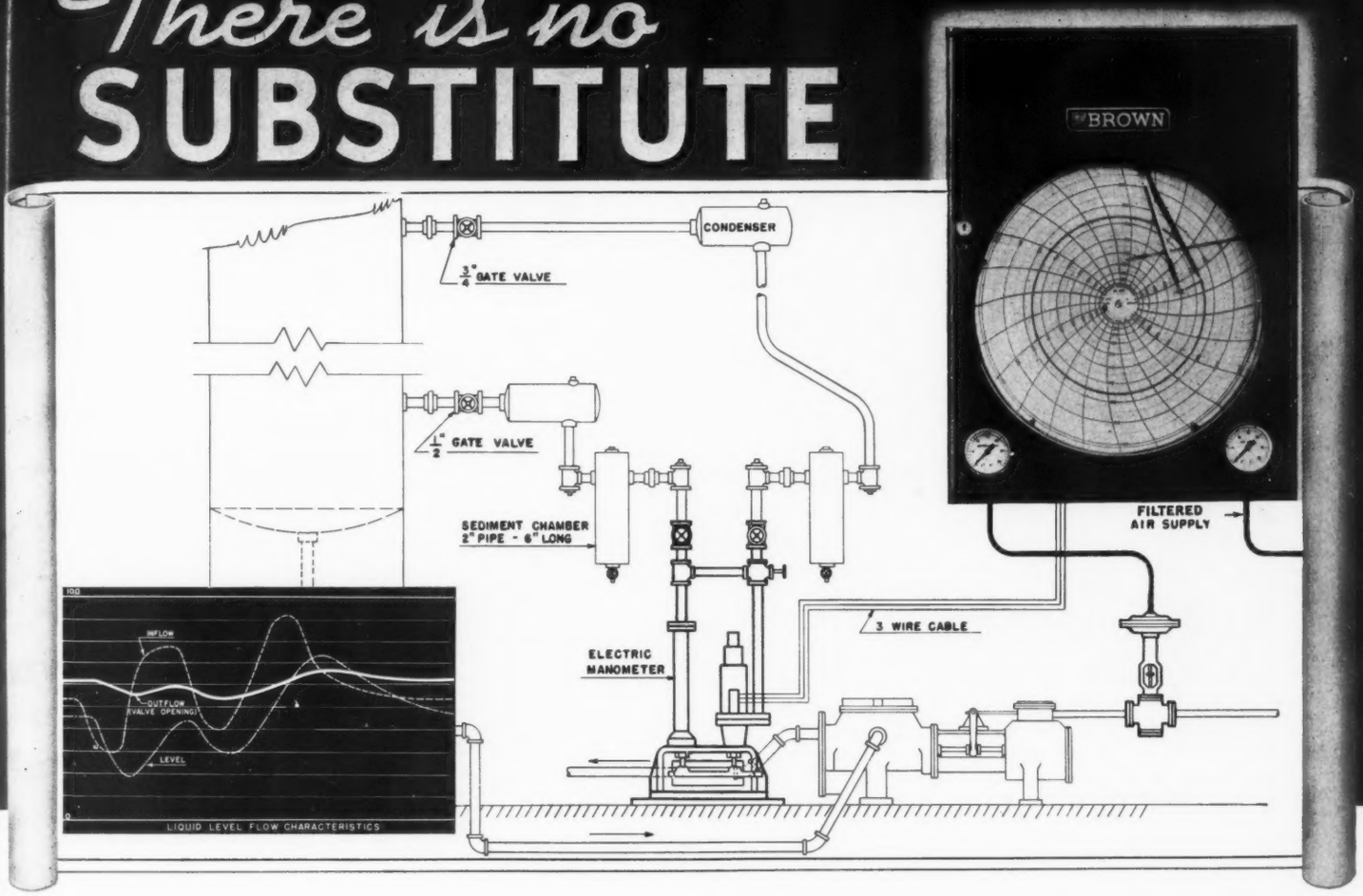
The LANDIS Receding Chaser Pipe Threading and Cutting Machine may effect a similar savings on many of your difficult threading operations.

DETAILS? Write us today for more information about the LANDIS Receding Chaser Pipe Threading Machine.

LANDIS MACHINE COMPANY, Inc.

WAYNESBORO, PENNA., U. S. A.

There is no SUBSTITUTE



In most continuous processes it is essential that the entire process be kept in balance —that is, the rate of processing to the units must be held at a steady, even level.

To smooth out these operations, the Brown Differential Type Meter offers many advantages not found in other types of level measuring mechanisms.

It permits effective use of every inch of available liquid storage space due to the fact that it has a range of from 2 to 20 times that of kidney-type float mechanisms.

The Brown Differential Liquid Level Recording or Indicating Controller is equipped with a fully automatic **Air-o-Line** pilot mechanism. Wide variations of inflow can be ironed out to give smooth outflow curves and steady operating conditions. The advantage of the Brown Controller is illustrated by the graphical analysis shown in the insert.

Brown Differential Type Liquid Level Controllers are available in either electrical, mechanical or pneumatic transmission type of meter body. The electrical and pneumatic types permit mounting the meter body adjacent to the vessel, while the controlling instrument is installed remotely.

For details, write THE BROWN INSTRUMENT COMPANY, 4498 Wayne Avenue, Philadelphia, Pa. Offices in all principal cities. Amsterdam-C, Holland: Wijdesteeg 4 —England: Wadsworth Road, Perivale, Middlesex—Stockholm, Sweden: Nybrokajen, 7.

BROWN *Air-o-Line* LIQUID LEVEL CONTROLLERS

THE BROWN INSTRUMENT COMPANY, PHILADELPHIA, PENNSYLVANIA
DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.
MINNEAPOLIS, MINNESOTA, AND 119 PETER STREET, TORONTO, CANADA

TO MEASURE AND CONTROL IS TO ECONOMIZE

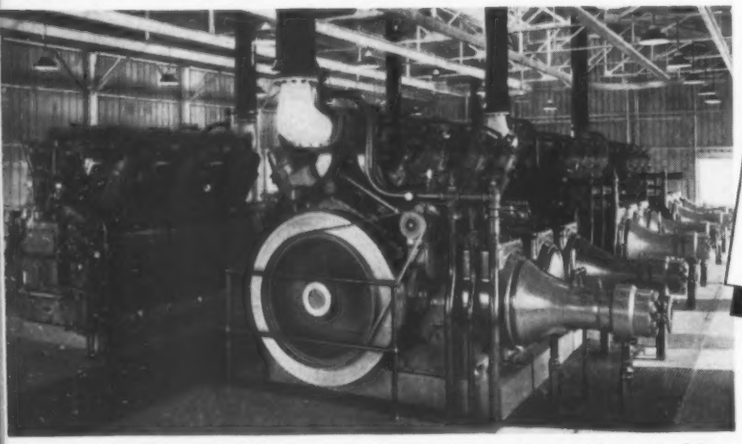
Good? Sure!...

Or They Wouldn't Order More!

Royalite Oil Company, of Canada, was the first purchaser of Type G-MV compressors. Here are three more 400-hp units recently installed by the same company in South America.

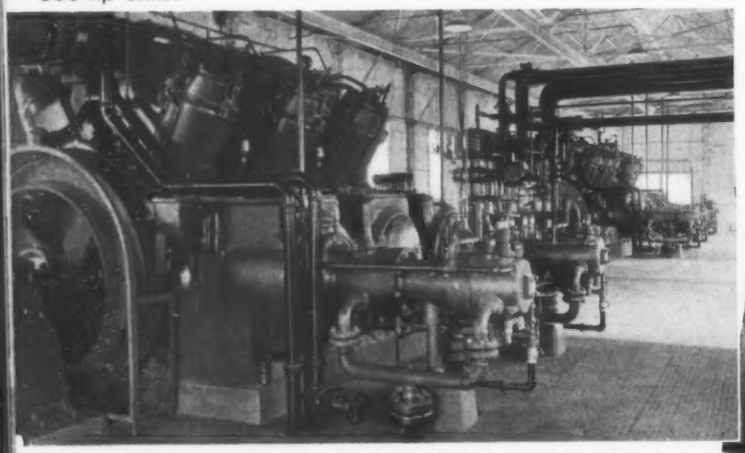
Type G-MV compresso units have gone int many plants as "tria horses." Invariably, they performed so efficiently... pleased hypercritical own- ers so well ... that orders for more G-MV's followed quickly!

There are good reasons for their success ... engineer- ing features by the dozens! If you want details, write for Bulletin G-MV.

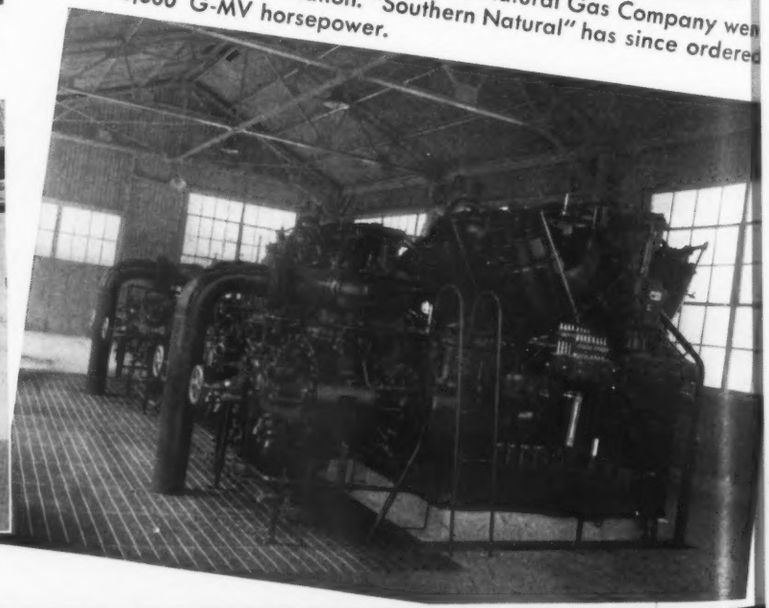


The first Type G-MV compressor sold to J. S. Abercrombie Company has been followed by thirteen more of these 600-hp units.

The first two G-MV's for Southern Natural Gas Company wen into their Selma station. "Southern Natural" has since ordered 16,600 G-MV horsepower.



Four 400-hp Type G-MV's for Tide Water-Seaboard compa- nies have been augmented by two "sixes" and another "four."



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"TAKE UP" with KELLOGG

How to produce speedily and economically 100-octane aviation gasoline required in the national defense program.

Find out how Kellogg-built high octane gasoline plants utilizing the latest and most efficient processes are now aiding in this vitally important program.

To take advantage of Kellogg's experience in all branches of processing, engineering and construction is one of the best ways for any refiner to help to "keep 'em flying."

KELLOGG

THE M. W. KELLOGG COMPANY
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EUROPEAN REPRESENTATIVE: Compagnie Technique des Petroles
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LICENSING AND CONSTRUCTION AGENTS under United States and foreign patents for: Catalytic Processes for Cracking, Reforming, Dehydrogenation, Alkylation, Desulphurization

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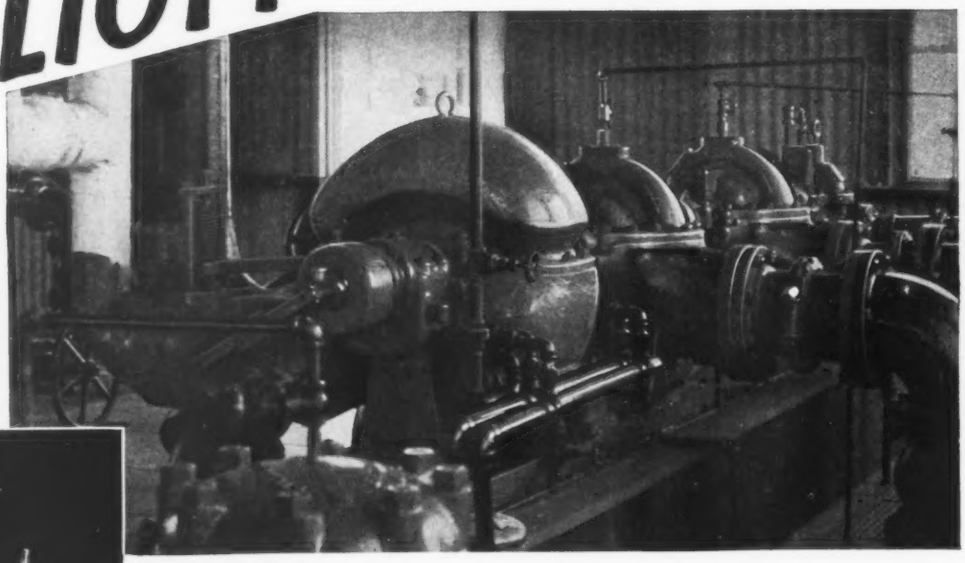
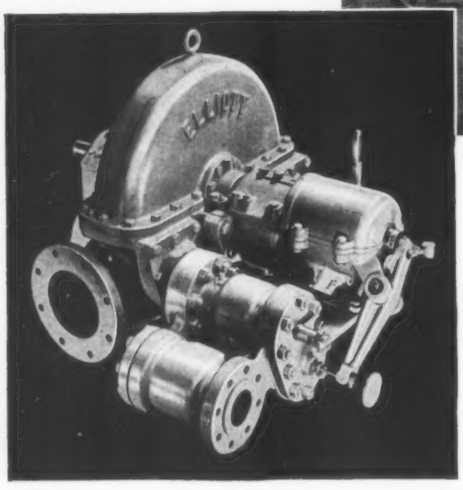
- JUIK Processes . . . . . for Lubricating Oil Refining with Propane and Phenol • Deasphalting • Dewaxing • Solvent Extraction and Acid Treating Plants

Catalytic Cracking Continuous Process
Hydroforming
Catalytic Polymerization
Alkylation
Thermal Cracking
Thermal Polymerization
Thermal Reversion
JUIK Processes for Lubricating Oil Refining

. . . so they said: "OK - make it ELLIOTT TURBINES!"



An Elliott 197-hp. turbine driving three pumps in tandem, in a natural gasoline plant. There are several tandem drives like this in this plant.



THE PLANT SUPERINTENDENT INSISTED—said that when it comes to turbines, proven operating results counted more than competitive bids. Pointed out that it was his job to keep things going and show a profit in plant operation, and he didn't want any trouble with his pump drives. Words to that effect.

So in this natural gasoline plant, eight Elliott turbines are doing a sweet job of driving various pumps, singly and in tandem, and are consistently demonstrating those qualities of dependability that have put thousands of them at work in refineries.

There is no sentiment involved in the liking of refinery engineers for Elliott turbines, but it is very real, for all that. Refinery engineers feel that their Elliott turbines make life just a bit easier for them, and make plant operation and profits just a bit more certain. That's all there is to it.

But there is plenty to the turbine itself. Why not ask for the Elliott Turbine Bulletin, and check on it.

ELLIOTT COMPANY

Steam Turbine Dept., JEANNETTE, PA.

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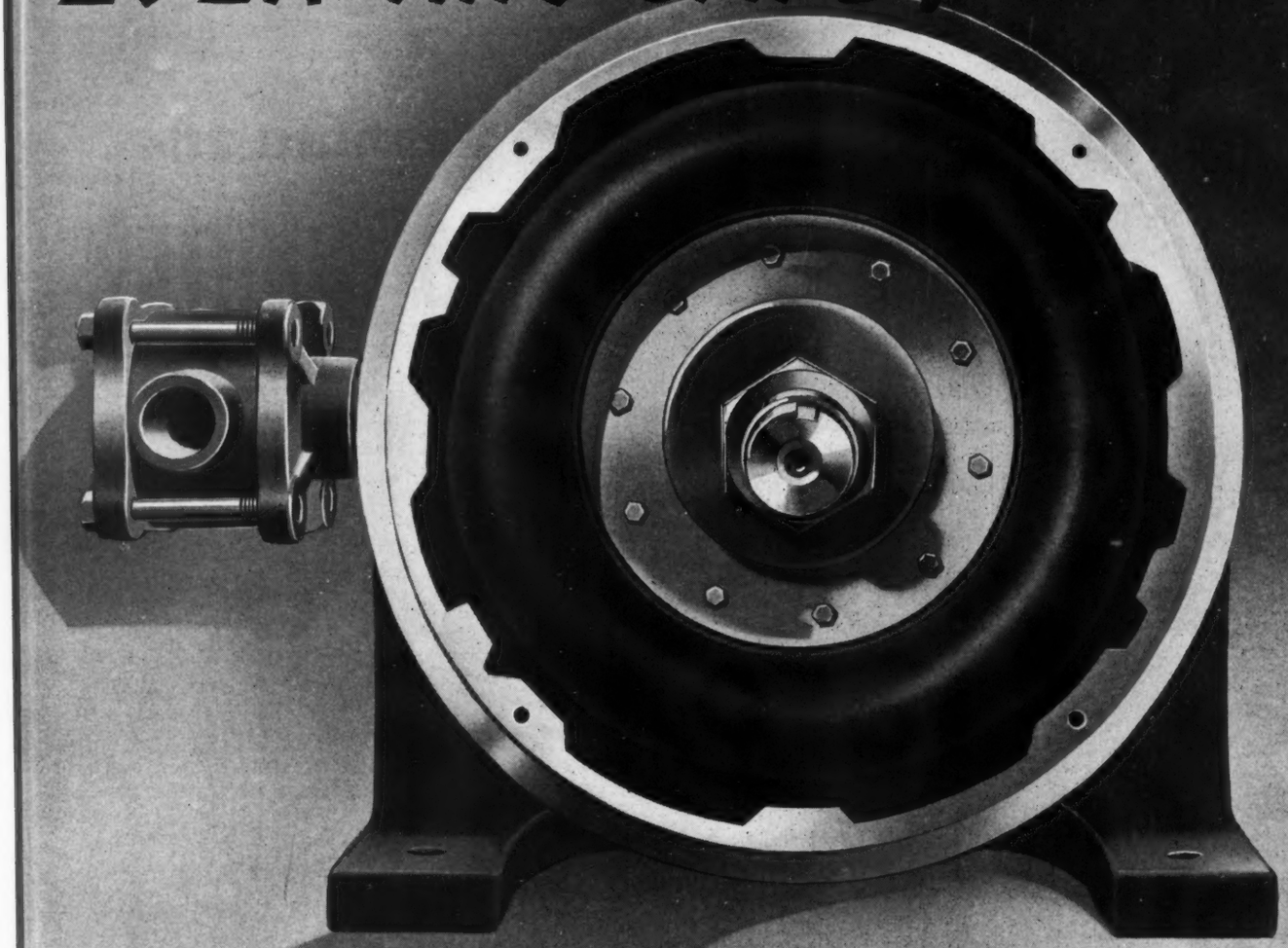
EVEN AIR GAPS!



Accurately ground stator bore of Louis Allis induction type motors helps to insure even air gaps and precision electrical balance.

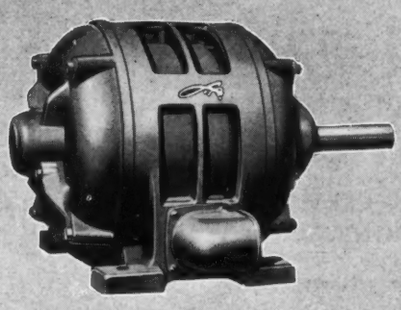
Precision fit, selected ball bearings, help to insure even air gaps.

And these—supported by close tolerance machining of stator housing and bearing brackets—and rigid multiple inspection—*insures even air gaps* in Louis Allis induction type electric motors.

Dynamically balanced, pressure cast one-piece rotors insure mechanically balanced as well as electrically balanced motors.

Firmly anchored, triple insulated stator windings—in a scientifically braced, extra heavy one-piece cast iron housing insures extra rigidity—and smooth flowing, dependable power on the very toughest jobs.

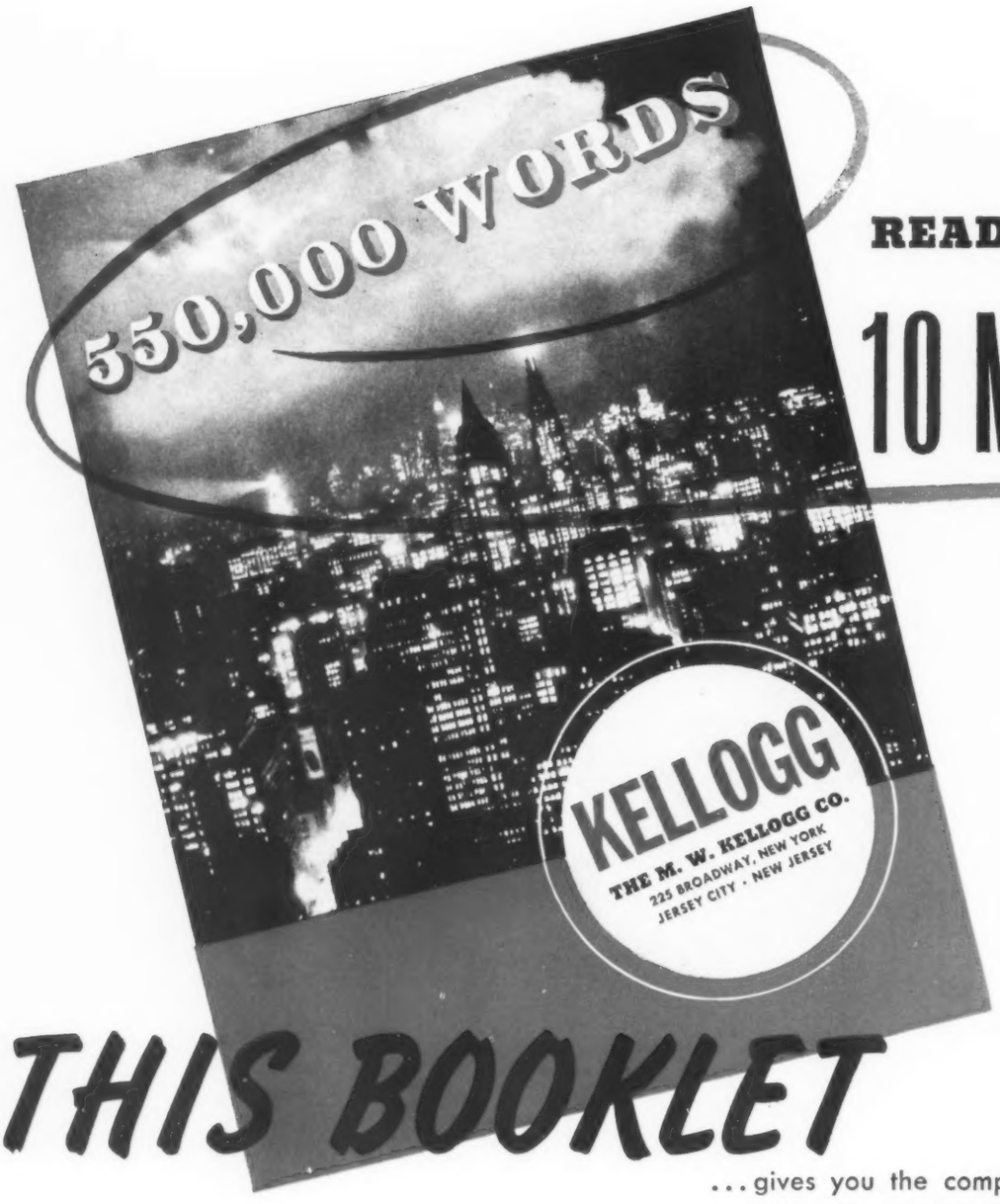
There is a size and type Louis Allis induction electric motor for every industrial requirement.



Write for a copy of our new illustrated catalog No. 701

We earnestly solicit your inquiry on your very next electric motor requirement.

THE LOUIS ALLIS CO., MILWAUKEE, WIS.



READING TIME

10 MINUTES

THIS BOOKLET

...gives you the complete picture story on the what, how and why underlying the long-standing and world-wide reputation enjoyed by Kellogg for the design, fabrication and erection of piping systems to the most exacting specifications.

Photographs of typical prefabricated units and complete installations in central stations, industrial plants and oil refineries are shown to illustrate the services rendered by The M. W. Kellogg Company.

Simply write on your firm's letterhead asking for a copy. Suggestion: Write Now!

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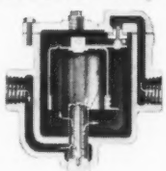

It's human to blame the boiler room for lack of steam, but the chances are 10 to 1 that the trouble is due to condensate clogging the steam coils or supply lines—or both.

If the avalanche of production has resulted in yells for more steam in your plant, consider what just one **SARCO BUCKET TRAP** could do at the most troublesome points in your plant.

It's a bear for punishment—it shoots out heavy loads of condensate rapidly, by means of a simple, sturdy valve mechanism that is positive and stands the hardest service. Pressures up to 900 lbs. Catalog No. 350.

113

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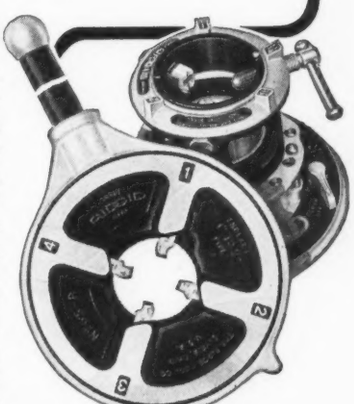

SPIN UP workholder, set cam post to pipe size, spin it down—turn workholder cam plate to size—put on the pipe, tighten one screw—and start threading! You won't believe how fast and easy till you have tried it—*a real saver of precious time and effort.* Dependable? This fully tested all-steel and malleable-alloy tool, with drop-forged tool steel cam plates and high speed steel chaser dies, does all you can ask of it—more smooth accurate threads on any pipe in less time than you've ever been able to cut before. Hundreds of thousands in use. Try this RIDGID No. 65 at your Supply House—*today!*

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CATALOGS . . . BULLETINS

Helpful Publications Which Manufacturers Will Be Glad to Send Free for the Asking

Automatic Valves

Foster Engineering Company, 109 Monroe Street, Newark, New Jersey, has compiled Catalog 70, a complete presentation of an extensive line of automatic valves and pressure regulating equipment for the refining and processing industries. Each item is presented in complete details with both photographic and diagramatic illustrations. The equipment is for liquids, steam and gas. Tables and graphs offer engineering information for a guide in selecting equipment for specific uses.

Information from the company is that: "a copy of this catalog will be sent to executives and engineers engaged in those industries serving national defense and if the request is written on their companies' letterheads."

Industrial Pumps

Pomona Pump Company, 206 East Commercial Street, Pomona, California, has issued a brochure of practical information concerning pump adaptation for a wide range of duties under varying conditions.

This brochure contains not only a profusion of illustrated case histories of varied application but also presents many practical drawings for laying in this type of pump.

Condensed Index

The Bristol Company, Waterbury, Connecticut, has issued a bulletin containing a condensed index of the products as well as the engineering services provided by the concern. The bulletin covers air-operated and electrically-operated automatic control instruments, recording and indicating instruments and telemetering instruments for recording and remote control.

Respirator

Mine Safety Appliances Company, Braddock, Thomas and Meade streets, Pittsburgh, has issued Dustfoe Bulletin, No. Cm-5, in which details of construction and use are given for recent improvements in M. S. A. Single Filter Dustfoe Respirator.

Motor Starter

General Electric Company, Schenectady, New York, has issued Publication GEA-3660, which explains in detail the design, construction and application of the new General Electric 2300-volt contactor high capacity motor starters.

The booklet tells how this contractor starter, which is designed for squirrel cage, synchronous and wound rotor motors, can be applied on a highly repetitive duty cycle and yet requires only a minimum of maintenance.

Heat Exchangers

Downington Iron Works, Downington, Pennsylvania, has issued its first general bulletin on heat exchangers, a new line as a standard product for this company. Illustrations and descriptive matter give details on six types of units for the petroleum refining industry.

Microphotometer

Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia, has published a new catalog along with its introduction of the Knorr-Albers Microphotometer to its line of equipment. The instrument is for recording spectrum line densities. The catalog, E-90(1), gives complete details of construction as well as adaptations to industry.

Filtration

Alsop Engineering Corporation, Milldale, Connecticut, has issued a new catalog, No. 941, which gives detailed information on new developments in the field of filtration. A section of the publication is devoted to the new sealed disc type filter, which is designed to make available several times the filtration speed and capacity previously available.

The first 10 pages of the 36-page catalog are devoted to improvements which have been made in the standard line of Hy-speed propeller type agitators.

Steam Traps

W. H. Nicholson & Company, Wilkes-Barre, Pennsylvania, has issued catalog No. 941, which gives details on the line of Nicholson steam traps. The industrial, expansion and weight operated types are described in detail and examples given of adaptations to plant use.

Compressors

Clark Bros. Company, Olean, New York, has issued a bulletin, 200-73, which gives details on Clark Angle-Type Steam-Driven Compressors. Requests for copies should be addressed to headquarters in Olean.

Socket Screws

The Bristol Company, Waterbury, Connecticut, has prepared a booklet of 10 pages to describe its line of hex socket screws, which includes set screws, socket head cap screws, socket head stripper bolts, pipe plugs, tee keys and screw driver type keys.

The folder illustrates the styles and gives detailed sizes, dimensions, prices and other information. The folder, No. 845, is available from company headquarters.

Recording Instruments

C. J. Tagliabue Manufacturing Company, Park and Nostrand avenues, Brooklyn, has a new catalog, No. 1210, "Tag Recording Instruments for Temperature and pressure." In addition to the new line of recording thermometers and recording pressure gauges, it gives complete data on mercury, fully-compensated mercury, vapor-tension and gas-filled tube system.

Proportioning Control

The Brown Instrument Company, Wayne and Roberts avenues, Philadelphia, has issued a new bulletin No. 85-18 entitled "The Brown Triple Function Proportioning Control System (Utilizing the Beck Mechanism)." This bulletin describes how the Brown Single Record control Potentiometer used in combination with the Beck Mechanism, produces optimum results where there are changes in load, fuel, pressure, heating value or where the time lag is high.

All information regarding this system is fully yet concisely presented. Descriptions of the individual functions of the system such as proportioning action, proportional reset action, timed reset action and initial approach setting are included.

The bulletin is fully illustrated, containing large, clear photographs of the Beck mechanism and Brown single record Control potentiometer. Also included are various diagrams showing the valve position of the individual functions and a photograph showing the system installed on a strip normalizing furnace.

Stainless Welding

Arcos Corporation, 401 North Broad Street, Philadelphia, has issued Arcos Technical Bulletin No. 5, which gives details for welding with stainless electrodes. It contains tables showing current values, weld metal characteristics, deposition data, heat treatment and applications of stainless and alloy products of the company.

Electric Control

General Electric Company, Schenectady, New York, has issued publication GED-972A, an eight-page booklet giving the complete story on Thy-mo-trol, the new G-E electronic control system for the operation of direct-current motors from alternating-current lines.

Containing photographs, a simplified chart, and diagrams, the publication tells how the Thy-mo-trol system not only provides stepless, wide-range speed control, but also performs the additional functions of starting, accelerating, protecting, and stopping d-c motors.

The single-dial speed control is discussed, and four typical Thy-mo-trol applications are given to round out the booklet.

Control Devices

The Brown Instrument Company, Wayne and Roberts Avenues, Philadelphia, has issued Catalog No. 8301, "Industrial Control Devices." The first few pages are devoted to fundamentals of automatic control. The three classes of automatic control, electric, pneumatic and combined electric pneumatic, are fully described.

The 56-page catalog has been written for both the engineer and the layman. Photographs illustrate 44 industrial controls and safeguards such as temperature controllers, pressure controllers, humidity controllers, float switches and combustion safeguards. Complete specifications and informative details are given for all types.

Cleaners

Ideal Commutator Dresser Company, 1274 Park Avenue, Sycamore, Illinois, has prepared a 4-page bulletin, describing its combination "3in1" cleaners. The units may be used as vacuum, as blowers or for spraying and are recommended for keeping equipment clean and for cooling machine while in operation.

Squeegee Pump

Downington Manufacturing Company, Huber pump division, Downington, Pennsylvania, has a folder of six pages giving full description of its new type pump, designated as a squeegee type. The new design in pumping consists of a flexible rubber tube, which is alternately squeezed and released in a rocking, squeegee manner so that the liquid or gas is breathed into and out of the tube.

Rubber Hose

United States Rubber Company, Rockefeller Center, New York, has issued a new hose manual, "Eight Plies of Useful Information." The book is in the form of an enlarged section of hose with each page representing one ply.

Creep Stress Data

The Babcock & Wilcox Tube Company, Beaver Falls, has compiled the latest creep-stress data on B&W Coroloys and other tubular materials for high temperature service on a technical data card, TDC-102-B. It is available by writing the company.

Automatic Control

Mason-Neilan Regulator Company, 1182 Adams Street, Boston, has released a new general catalog, No. 41, which describes many of the standard items in the Masoneilan line. Both pictures and diagrams are used to show workings of equipment. Technical information is included in the text.

Rubber Base Compounds

Primoid Products Corporation, 103 Park Avenue, New York, has issued a new bulletin describing its rubber-base compounds, designed for stopping leaks and seepage through brick, concrete and other types of masonry walls. When applied to metal the products will prevent corrosion or rusting.

Products

Koppers Company, Tar and Chemical division, Koppers Building, Pittsburgh, has published an eight-page folder which summarizes all of Koppers' important products, plants and services. The list ranges from Koppers coals and coke to light oil plants and purification systems; from valves, castings, forgings, couplings and piston rings to roofing, tar-base paints, and pressure-treated timber products. Two pages are devoted to the uses, technical description and characteristics of tar acids, tar acid oils, and coal tar solvents.

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A

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Butane-Propane Gases

SECOND EDITION—(Revised, September, 1938)

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WESTON all-metal thermometers are guaranteed accurate within 1% over the entire scale, and are available in types, ranges, scale diameters and stem lengths to suit many industrial applications.

A bulletin containing complete information is available. Weston Electrical Instrument Corporation, 655 Frelinghuysen Avenue, Newark, New Jersey.

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The *practical* lab thermometer. Has large, easy-reading scale. Stainless steel construction. Accuracy, ½ of 1% over the entire scale. Ask for bulletin.

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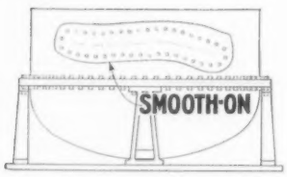
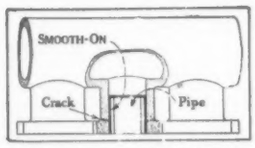
A PLANT NECESSITY *for* QUICK *repairs*



Cracked evaporator shell. Repair patch covers crack.



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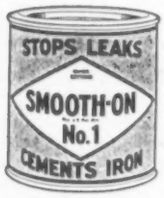

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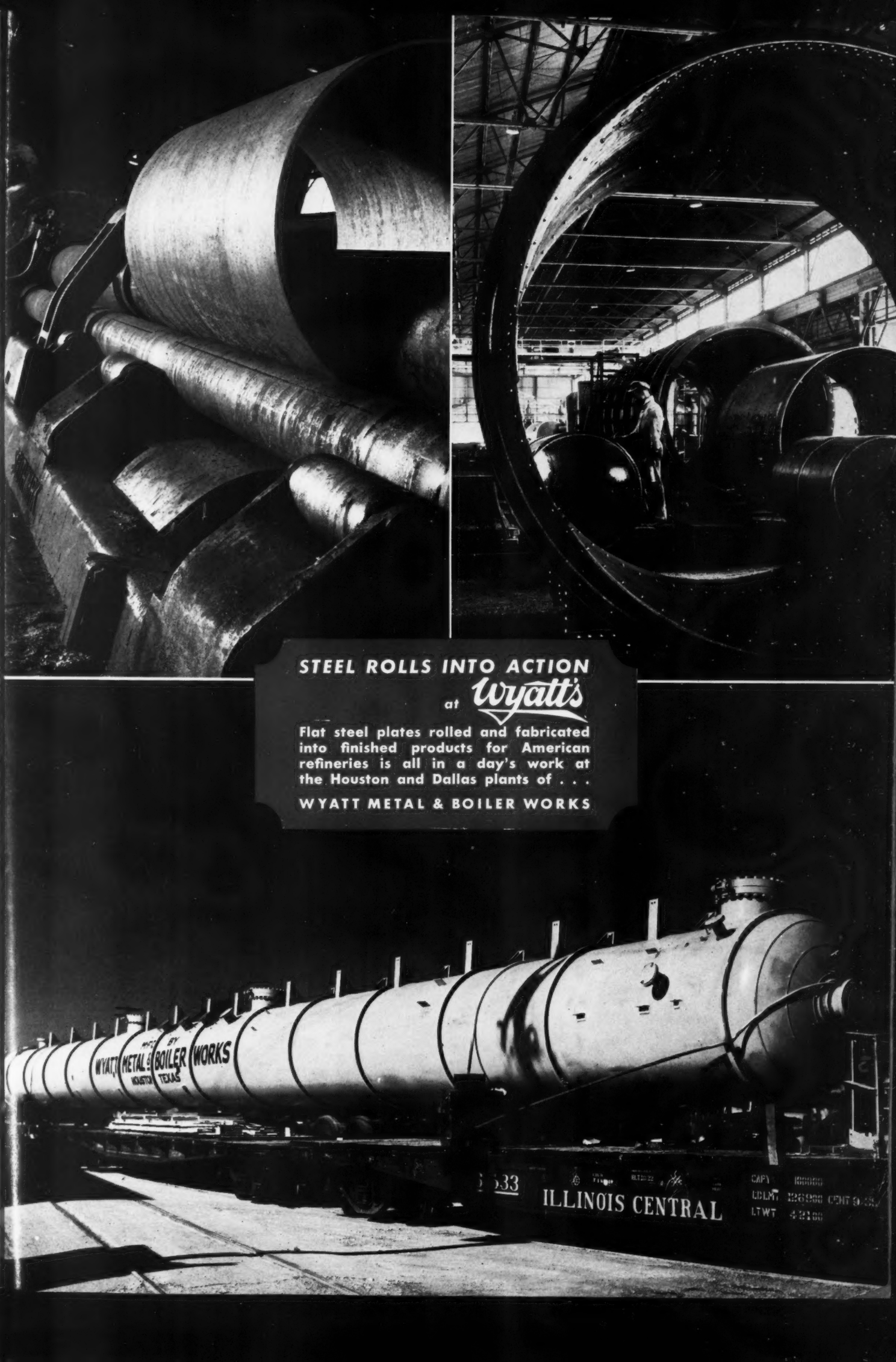
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PLATE 956 — McDonald Slo-Self Closing Loading Line Valve—*Patented*—Angle Type.

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